Outmigrant Trapping of Juvenile Salmonids in the Lower Stanislaus River Caswell State Park Site 1997

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EXECUTIVE SUMMARY

We operated two rotary screw traps side-by-side in the lower Stanislaus River near Caswell State Park (river mile (RM) 8.6) from March 19 through June 27, 1997 to estimate an index of abundance of juvenile fall-run chinook salmon migrating out of the Stanislaus River during this time period. We estimated the capture efficiency of the traps by releasing 4 groups of marked hatchery chinook and 1 group of marked natural chinook, about 1/4 mile upstream of the traps. Recovery rates of these marked fish varied from 1.6% to 3.6%. Variation in capture efficiency for both traps combined was accounted for by a logistic regression on river flow and turbidity, which was different than the method used in this study in 1996. The method used in 1997 provided more accurate passage estimates by incorporating 1996 and 1997 trap efficiency tests, flow, and turbidity into the same model.

The estimated number of juvenile chinook salmon that migrated past the traps between March 19 and June 27, 1997 was 47,000 with an approximate 95% confidence interval of 34,000 to 59,000. The majority of juvenile chinook captured in 1997 were between 80 and 109 mm. Lengths gradually increased over the course of sampling, and ranged from about 70 mm in late March to about 95 mm in mid-June. The gradual increase in mean lengths over time in 1997 was similar to the pattern in 1996, except that mean lengths were slightly smaller in 1997 on the same dates. Sampling began after fry emergence was nearly complete. No yearling chinook were captured. We captured 11 rainbow trout/steelhead, ranging in size from 197 to 275 mm. All of the fish showed advanced smolting characteristics.

Although passage estimates fluctuated substantially between days, the number of chinook passing the traps did not show a distinct seasonal peak as was evident in most previous years. The pattern of outmigration in 1997 showed only a weak influence from changes in streamflow. Even though there were several large changes in flow, increases in outmigration following these changes were small and lasted only a few days. The number of chinook passing Caswell decreased in late May, and few chinook migrated out in June. River flow and turbidity were unusually high in January and February of 1997, so significant numbers of fry probably outmigrated before the traps were installed.

Based on additional trap efficiency tests and a revised model for predicting trap efficiency, we re-analyzed the 1996 outmigration data. The revised estimate of chinook outmigrants between February 6 through July 1, 1996 was 105,000 with an approximate 95% confidence interval of 46,000 and 165,000. This estimate was somewhat higher than the estimate of 71,000 to 78,000 given in the previous report for 1996 (Demko and Cramer 1997). The original chinook passage estimate at the Caswell site (RM 8.6) in 1996 was only 25% of that estimated at the Oakdale site (RM 40), for the same time period. The revised passage estimate (105,000 versus 71,000) is 37% of the Oakdale estimate, somewhat higher than the original estimate. The difference in estimated passage still suggests that there may be substantial mortality to juvenile chinook in the 34 miles between the Oakdale and Caswell sites. However, more focused studies will be needed to estimate in-river survival rates.

ACKNOWLEDGMENTS

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We thank the Tri-Dam Board of Directors, as well as Rick Barzan, Manager of Oakdale Irrigation District and Rick Martin, Manager of South San Joaquin Irrigation District who loaned equipment and manpower to help carry out this study.

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INTRODUCTION

Sampling at the Caswell site will be included in the Central Valley Project Improvement Act (CVPIA), Comprehensive Assessment and Monitoring Program (CAMP) intended to assess the relative effectiveness of the Anadromous Fish Restoration Plan (AFRP). The objective of the juvenile monitoring program of CAMP is to assess the relative effectiveness of categories of restoration actions recommended in the CVPIA Anadromous Fish Restoration Plan. The goal of the AFRP is to double anadromous fish populations in streams of the Central Valley, so the monitoring described here at the Caswell site, combined with similar sampling in other major streams of the Central Valley, will serve as one measure of success for the AFRP and provide the feedback information needed for adaptive management.

STUDY OBJECTIVES FOR 1997

Sampling at the Caswell site in 1997, reported here, had three objectives:

Ø Estimate the number of juvenile fall-run juvenile chinook salmon migrating out of the Stanislaus River in 1997,

Ù Determine the size and smolting characteristics of juvenile chinook salmon and rainbow trout/steelhead migrating out of the Stanislaus River,

Ú Identify factors that influence the time, size and number of juvenile chinook salmon and rainbow trout/steelhead migrating out of the Stanislaus River.

A fourth study objective, to determine migration rates and survival of juvenile chinook through the Stanislaus River, could not be studied in 1997, because no hatchery fish were available from the MRFF to mark and release above Oakdale.

SUMMARY OF PREVIOUS MONITORING

Rotary screw traps have been used since 1993 to monitor timing and relative abundance of juvenile salmonids outmigrating from the Stanislaus River. Sampling has been conducted near Oakdale (RM 40) and near Caswell State Park (RM 8.6) by either California Department of Fish and Game (CDFG), US Fish and Wildlife Service (USFWS) or S.P. Cramer and Associates, Inc. (SPCA)(Table 1). Target species include fall-run chinook salmon and steelhead/rainbow trout. A summary of sampling in each past year follows.

Table 1. Date, location and number of rotary-screw traps operated in the Stanislaus River, 1993 - 1997.

Year	Trap Location	Number of Traps	Start Date	End Date	Flow-Year Type
1993	Oakdale	1	Apr 21	Jun 29	Low
1994	Caswell	1	Apr 23	May 26	Low
1995	Oakdale	1	Mar 18	Jul 1	Low
1995	Caswell	2	Mar 27	May 26	Low
1996	Oakdale	2	Feb 1	Jun 8	High
1996	Caswell	2	Feb 5	Jul 2	High
1997	Caswell	2	Mar 19	Jun 27	High

In 1993, the first year of screw trap sampling in the Stanislaus River, one trap was fished at the Oakdale site for a portion of the outmigration period. The daily number of outmigrants was estimated from the results of two mark-recapture tests.

In 1994, one trap was operated at the Caswell site and no sampling occurred at the

Oakdale site. Juvenile chinook catches were low in 1994, and no daily or seasonal abundance index was estimated.

In 1995, two traps were fished at the Caswell site. Catches of natural migrants were low, and so were trap efficiencies estimated from recoveries of marked fish. However, since sampling was also conducted at Oakdale that year, it was possible to compare the size and timing of juvenile chinook between the up and downstream trapping locations. Catches were much greater at Oakdale, and screw trap efficiency was estimated there through the release of 20 groups of marked natural or hatchery chinook.

In 1996, we fished two rotary-screw traps at Caswell and one screw trap at Oakdale. Sampling began earlier in 1996 with a goal of estimating the total number of juvenile chinook outmigrants. We began sampling at Oakdale and Caswell in early February, and found that fry were already migrating. We modified the trap set-up at Caswell to increase capture rates and released 15 groups of marked fish to estimate trap efficiency. Recapture rates varied from 0 to 12.08% with variation in capture efficiency best accounted for by a logistic regression on turbidity.

Large differences in estimated passage at Oakdale and Caswell in 1996 suggested that there may have been high mortality to juvenile chinook in the 34 miles between the Oakdale and Caswell sites. However, more focused studies will be needed to estimate in-river survival rates.

DESCRIPTION OF STUDY AREA

The headwaters of the Stanislaus River originate on the western slope of the Sierra

Nevada Mountains. The Stanislaus River and its tributaries flow southwest to confluence with the San Joaquin River on the floor of the Central Valley (Figure 1). The San Joaquin River flows north and joins the Sacramento River in the Sacramento-San Joaquin Delta. The Stanislaus River is dammed at several locations for the purposes of flood control, power generation and water supply. Water uses include irrigation and municipal needs, as well as recreational activities and water quality control.

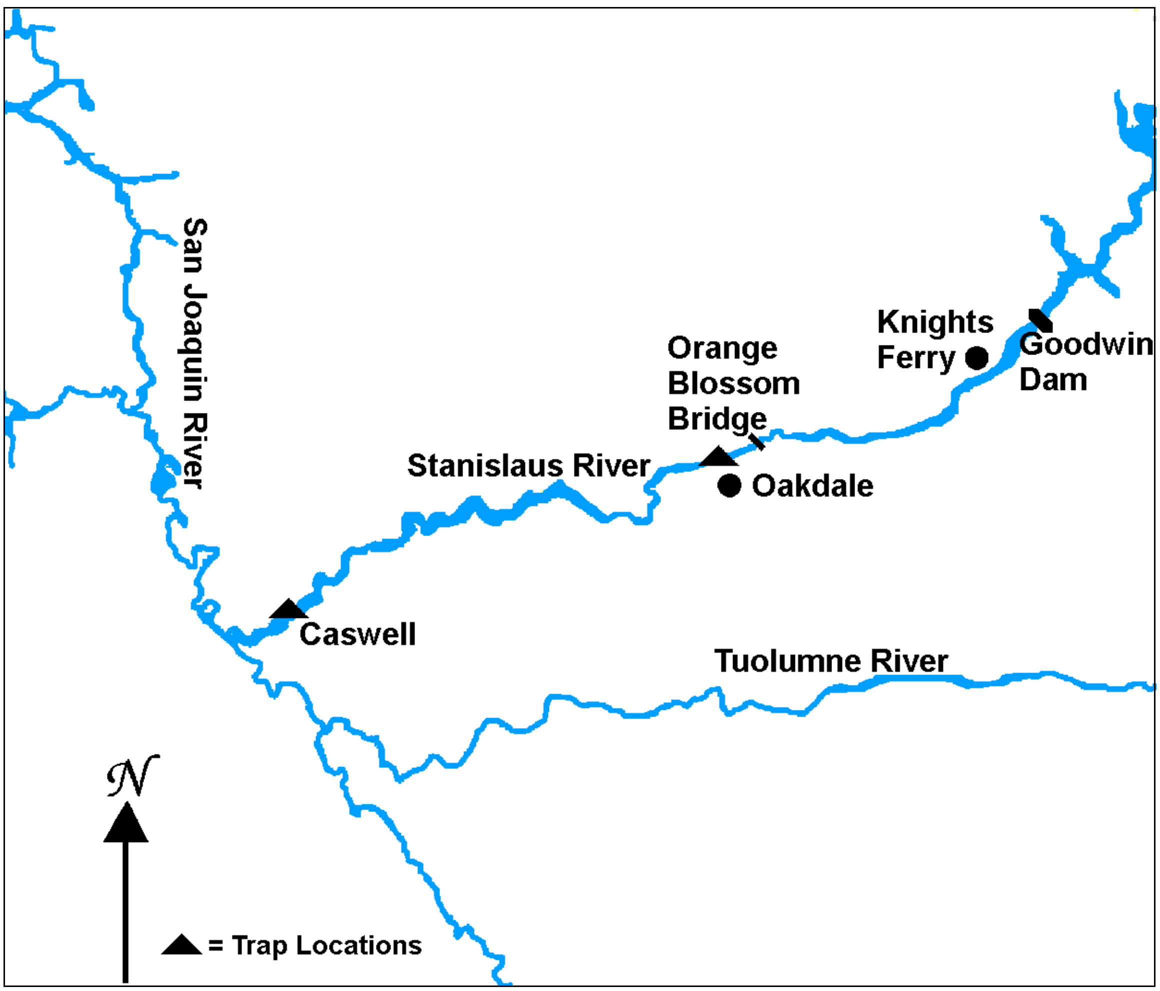


Figure 1. Location map of study area on the Stanislaus River.

Goodwin Dam, approximately 58.4 river miles (RM) upstream from the San Joaquin River confluence, blocks the upstream migration of anadromous fish. The lower river supports fall-run chinook salmon spawning between the town of Riverbank (RM 34) and Goodwin Dam (RM 58.4). Resident rainbow trout rear in the 10-20 miles of Stanislaus River below Goodwin Dam, and adult steelhead are occasionally observed, but it is not known whether a distinct anadromous population is present.

Throughout this report, we reference river miles on the Stanislaus River. River miles were determined with a map wheel and 7.5 minute series USGS quadrangle maps, (Knights Ferry, 1987 and Oakdale, 1987). The estimated river miles of our trapping locations and key area landmarks are:

Knights Ferry Bridge	RM 54.6
Orange Blossom Bridge (OBB)	RM 46.9
Highway 120/108 Bridge	RM 41.2
Oakdale Trapping Location	RM 40.1
Caswell Trapping Location	RM 8.6

METHODS

JUVENILE OUTMIGRANT MONITORING

Sampling Gear

We fished two rotary-screw traps side-by-side in the mainstem of the lower Stanislaus River near Caswell State Park to capture juvenile chinook salmon as they migrated downstream. The screw traps, manufactured by E.G. Solutions in Eugene, Oregon, each consisted of a funnel shaped core suspended between two pontoons (Figure 2). Each trap was positioned in the current so that water entered the 8 ft wide funnel mouth. Water entered the funnel and struck the internal screw core, causing the funnel to rotate. As the funnel rotated, fish were trapped in pockets of water forced rearward into a livebox, where captured fish could not escape. Each trap was held in place with 1/4 inch cable fastened to large trees upstream on the north bank. The downstream force of the water on the traps kept the cables near the water surface. Buoys marked the location of the cables for human safety. Although there is some recreational use of the river near the traps by small boats, canoes, and anglers in float tubes, the majority of river use in the vicinity of the State Park occurs downstream from the trap site.

Trap Site Preparation

The Caswell trapping location was chosen by CDFG in 1994 since it was the farthest location downstream with adequate access to install and monitor the traps. In 1997, we fished the traps in the same position used in 1996, which was upstream approximately 100 yards from the site fished in 1994 and 1995. The trap nearest the left bank (looking upstream) was designated the north trap and the trap nearest the right bank was designated the south trap. These designations are the same as those used in the study in 1995 and 1996.

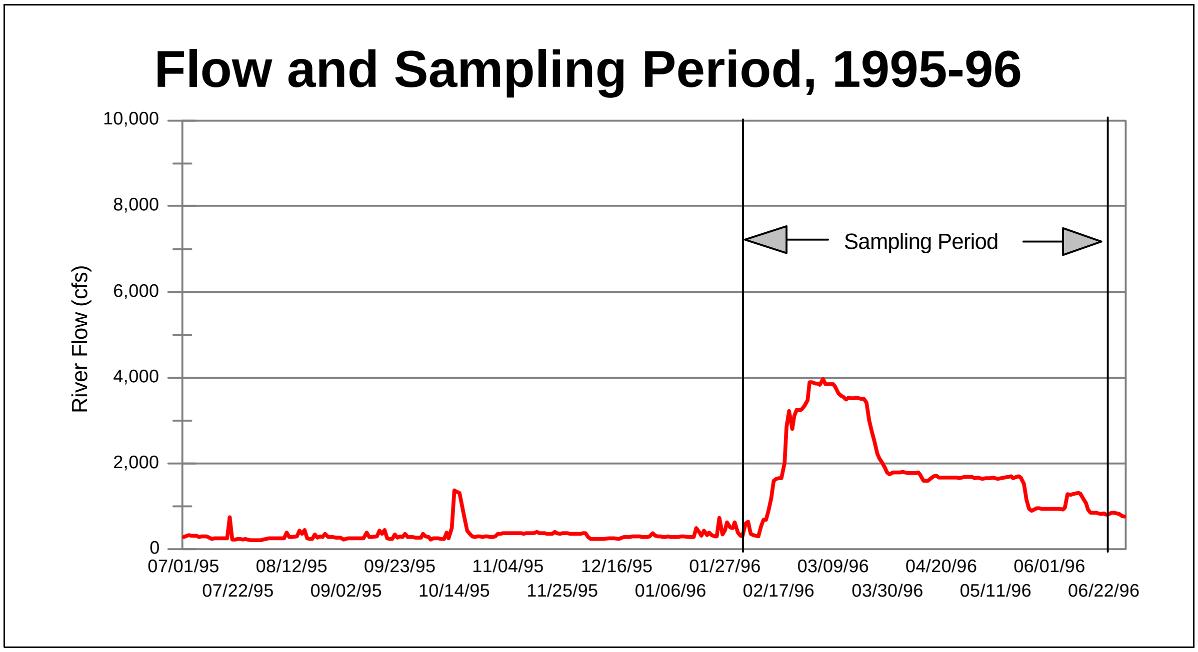
Figure 2. Photographs of the rotary-screw traps fishing near Caswell State Park. The buoys marked the position of the cables to prevent entanglement with river users.

In 1997, we planned to construct a sandbag deflecting wall extending out from the south bank to increase water velocities and trap efficiencies. Due to high river flows in 1997, we were not able to construct the wall. Unusually high precipitation during late December and early January caused river flows to rise and forced upstream reservoirs to release high flows for flood control purposes through April. Although we planned to construct the wall to withstand normal spring pulse flows of about 2,000 cfs, flow was over 7,000 cfs for most of January and February (Figure 3).

Although we were not able to construct the primary sandbag wall, there were about 750 sandbags extending approximately 5 ft. out from the north bank, where they were placed in 1996. Similar to 1996, the trap nearest the north bank fished about 10 ft. downstream of this wall and approximately 5 - 7 ft from the bank, in an area where the velocity was highest.

Safety Measures

Although recreational use of the river in this area was relatively light, we took precautions to warn park visitors and river users of the inherent dangers associated with screw traps. Two signs with large letters were placed upstream from the traps to warn river users traveling downstream towards the traps. The first sign (3/4 mile upstream) warned of an "Instream Obstacle Ahead" and recommended portaging on the left bank. The second sign (150 yards upstream) said "Danger Ahead - Stay Left". An arrow also pointed in the direction of the left bank. The signs were approximately 4 ft x 4 ft with black letters on a neon background. Flashing lights, similar to ones seen on roadside construction signs, were also placed on the traps to increase visibility at night.



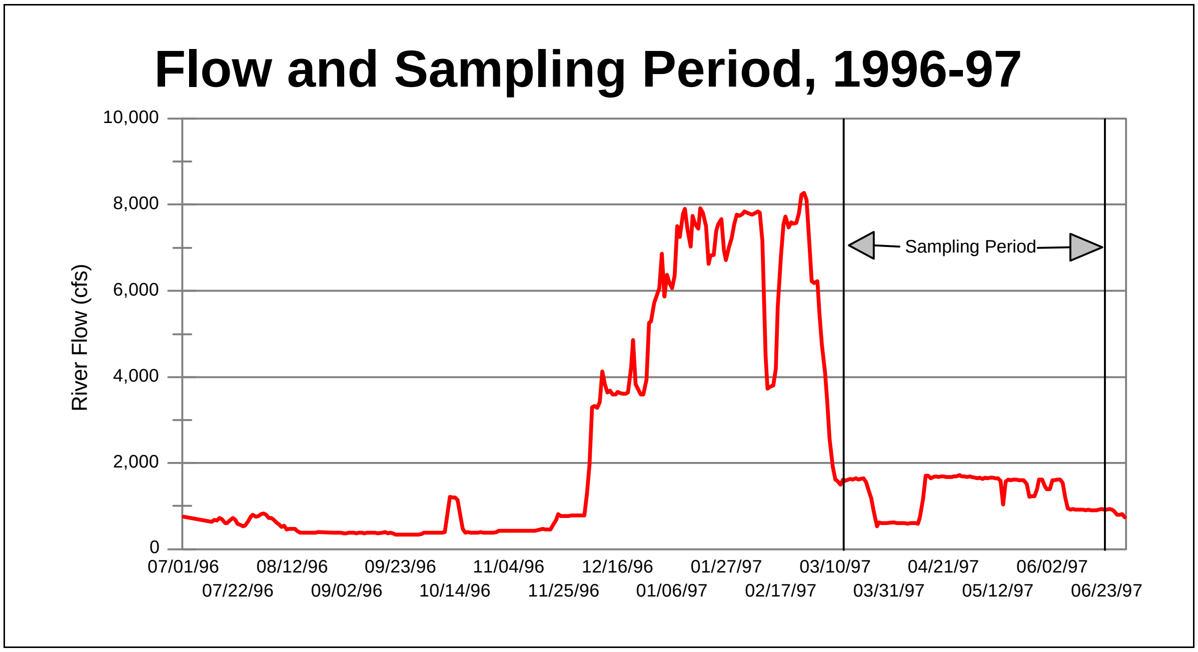


Figure 3. Outmigration sampling period in relation to Stanislaus River flow at OBB during 1996 and 1997.

To discourage people along the banks from swimming or floating towards the traps, we also placed numerous warning signs at conspicuous places along the banks. The signs warned of drowning danger near the traps as well as to "keep out" and "private property". The signs were in English and Spanish.

Trap Monitoring

High flows throughout January and February significantly delayed the start of sampling in 1997. We installed the rotary-screw traps on March 17 and 18, and began retrieving catches the morning of March 19 (Figure 3). Monitoring continued until June 27 and the traps were removed June 28. Sampling therefore did not cover the entire period of fall-run chinook salmon outmigration, typically January through June.

The traps were fished 24 hours per day, 7 days per week. Each morning we removed the contents of the livebox, counted and recorded all fish captured and cleaned the trap and livebox. It was often necessary to clean the traps again in the afternoon to clear away debris accumulated against the funnel walls and in the livebox. At times of high turbid flows and when we had recently released marked fish, we retrieved trap catches both in the morning and during the day to document daytime catches of juvenile chinook. Following the release of marked hatchery fish, we monitored the traps often until we were no longer recapturing marked fish.

During natural freshets when fish would accumulate in the livebox, we monitored the trap more frequently to reduce mortality of juvenile chinook. Plastic mesh fence panels were placed in the rear and side portions of each livebox to provide fish with areas of refuge and to minimize stress and mortality. The fences consisted of ½ in. plastic mesh fastened to pipe frames. The mesh caught wood and plant debris while allowing fish to pass through.

We measured a random sample of 30 chinook from each trap every morning. We also measured all rainbow/steelhead and all yearling chinook.

Smolt Appearance Rating

We recorded the external appearance of smolting characteristics for each juvenile chinook and rainbow trout measured. Smolting appearance was rated on a scale of 1 to 3, with 1 an obvious parr and 3 an obvious smolt. Since rating external smolting characteristics is by nature very subjective, we tried to have the same person rate chinook throughout the sampling period. The same person conducted the ratings about 80% of the time, with two other technicians conducting the remaining 20% of the ratings.

TRAP EFFICIENCY TESTS

Release Groups

Four groups of marked hatchery chinook salmon were released to estimate trapping efficiency on May 28 and 29 (Table 2 and Appendix 2). The CDFG supplied the hatchery fish from the Merced River Fish Facility (MRFF). Of the 4 groups, 1 group was marked by ink inoculation by the CDFG and the other 3 groups were marked by ink inoculation by us. The CDFG group was marked at the MRFF a few weeks prior to release. We marked the other groups on May 27, the day prior to release.

Table 2. Release data for marked chinook used to test capture efficiency of the rotary-screw traps at Caswell State Park during 1997.

Date of Release	Applied Mark [1]	Designated Mark	Total # Marked	Origin	Mark Retention	Start Release Time	End Release Time	Average [2] Daily OBB Flow (cfs)
4/7 - 4/11	TCBN	C1	182	Natural	100	---	---	---
28-May-97	BCBH	C2	2065	Hatchery	95.3	2200	2230	1608
28-May-97	TCBH	C3	1500	Hatchery	100	2245	2315	1608
28-May-97	AFBH	C4	1500	Hatchery	100	2330	2400	1608
29-May-97	AFGH	C5	1872	Hatchery	100	15	45	1608

[1] First two letters denote mark location (e.g. bottom caudal), third letter denotes dye color and fourth hatchery or natural origin of fish.
[2] Average daily flow on May 28, 1997. Average flow on May 29 was 1615 cfs. (California Data Exchange Center (CDEC) Internet site)
C1 group were natural fish captured in the traps and released each night between May 7 and May 11.

The hatchery fish were transported to the release site 1/4 mile upstream of the trap on the day prior to release and were marked there. The group marked at the MRFF by CDFG were marked blue on the bottom lobe of the caudal fin (BCBH). The groups marked by us were top caudal blue (TCBH), anal fin blue (AFBH) and anal fin green (AFGH). Once marked, fish were transferred to free-standing net pens in the river where they were allowed to recover for approximately 24 hours prior to release. The number of marked fish in each group ranged from 1,500 to 2,065. The 4,900 hatchery fish we marked had nearly 100% marked recognition after one day.

In addition to releasing hatchery fish to estimate trap efficiency, we also marked and released one group of 182 natural migrants between April 8 and April 12 (Table 2). The fish were captured in the screw traps, marked, and held until the following night when they were released. Even though the fish were released on different days, all the fish were dye marked with the same mark, blue top lobe of the caudal fin (TCBN). The fish were not measured or checked for brand clarity prior to being released. We used the mean length on the day the fish were captured as the mean length at release and brand clarity was assumed to be 100%.

Holding Facility and Transport Method

The fish were transported in two large, aerated transport containers and transferred to free standing net pens measuring 4 ft x 4 ft x 4 ft and 2 ft x 3 ft x 3 ft. The net pens consisted of 3/16 in. Delta mesh sewn onto frames constructed of ½ in. PVC pipe. The pipe was filled with sand so it would sink and rest on the river bottom. The net pens were located at the release location so fish would not have to be moved at the time of release. The release location was about 1/4 mile upstream from the trap in an area of low velocity. Plywood was placed on top of the nets to provide shade and protection from predators.

Marking Procedure

Juvenile chinook were marked by dye inoculation. We used a MadaJet inoculator to inject Alcian Green and Alcian Blue dyes (Sigma Chemical Company, St. Louis, Missouri) into the fins of hatchery chinook (Hart and Pitcher 1969). The dyes were chosen because of their known ability to provide a highly visible, long lasting mark. Before marking, fish were anesthetized with MS-222 (Schoettger and Steucke 1970). Once anesthetized, fish were inoculated by placing the tip of the MadaJet against the caudal or anal fin. Minimal pressure was applied as dye was injected into the fin rays. Only one mark was applied to each fish, and fish in each group received the same mark. Location of the mark was varied between groups so that each group could be uniquely identified. The CDFG used similar procedures to mark the bottom caudal blue group (C2) supplied to us.

Prerelease Sampling

Marked fish were sampled for mean length and brand clarity beginning at 0700 hours the day after marking. We began releasing fish at 2200 hours that night, allowing approximately 15 hours to recover from the stress of handling prior to release. Either 50 or 150 fish were randomly removed and anesthetized from each distinctly marked group. Mark clarity was rated as good, present but not identifiable, or absent. “Good” meant the mark was present and the color was recognizable. “Present but not identifiable” meant that a mark was present but the color was not recognizable. “Absent” meant no mark was evident.

The proportion of fish found to have clear marks in each group was used to estimate the actual number of fish released. Only one group had less than 100% clear and identifiable marks (BCBH 95%) and as a result we evaluated 150 individual fish from that group. The number of BCBH fish released was estimated by the expression:

number released = proportion mark retention * number in group.

Release Procedure

Fish were released directly from the net pens in which they were held. A dip net was used to remove and release about 50 fish per minute. The time required to release each marked group was 30 minutes. This protracted release procedure was similar to the procedure used in 1996. The gradual release of fish was intended to prevent the fish from behaving as a single school and rather to disperse them in time and space as natural migrants would. Release of each mark group was separated by 15 minutes.

MONITORING OF ENVIRONMENTAL FACTORS

Flow Measurements

Daily flow of the Stanislaus River was obtained from the California Data Exchange Center (CDEC). All river flows cited throughout this report were those measured at the Orange Blossom Bridge by the US Geological Survey (USGS). The flow data are daily averages, so instantaneous flows during freshets were higher. Depth-velocity profiles made in front of the traps are given in Appendix 3.

We used two methods to measure the velocity of water entering the trap. First, we measured water velocity at the time we checked the trap with a Global Flow Probe, manufactured by Global Water (Fair Oaks, CA) (Appendix 4). The probe malfunctioned on two occasions and it was necessary to return it to the factory for repair. There are no velocity data on those days. We also estimated an average daily trap rotation speed for each trap. The time, in seconds, for one revolution of each trap was measured every morning. A stopwatch was used to time three separate rotations of each trap.

Water Temperature and Turbidity

Daily water temperature was measured with a mercury thermometer at the trap site. An Onset StowAway recording thermometer was also installed to record water temperature once per hour throughout the sampling season. Daily average temperature was derived by averaging the 24 hourly measurements. Temperature data are presented in Appendices 5 and 6.

Turbidity was measured each day with a LaMotte turbidity meter, Model 2008. A water sample was collected each morning and later tested at the field station. Turbidity was recorded in Nephelometric Turbidity Units (NTU's). Turbidity data are presented in Appendix 6.

OAKDALE TRAPPING SITE

Rotary-screw trap sampling was not conducted at the upstream Oakdale site (RM 40) in 1997.

DATA REPORTING

Graphs and tables in this report show only one sample period per day, even when there may have been as many as six samples per 24 hour period. Data were summarized from 12:01 pm one afternoon until noon the next day and were assigned to the day of morning sampling. For example, fish that entered the trap at 7 pm on March 26 would have been reported in the catch for March 27.

RESULTS

OBJECTIVE 1: ESTIMATE THE NUMBER OF JUVENILE CHINOOK SALMON MIGRATING OUT OF THE STANISLAUS RIVER IN 1997.

During the preparation of this report, Objective 1 was expanded to include a re-analysis of the 1996 outmigration data. Additional trap efficiency tests in 1997, and the refinement of statistical procedures used to estimate the number of chinook passing Caswell each day, enabled us to make more accurate passage estimates than those made in 1996, as described in the following report sections.

Trap Catches of Chinook Salmon

From March 19 to June 27, we captured a total of 2,357 juvenile chinook in the screw traps (compared to 1,791 during the same time period in 1996) (Figure 4). The south trap consistently captured more juvenile chinook (1,949) than the north trap (408) (Figure 4), an occurrence that was also true in 1996 (Demko and Cramer, 1997). The traps operated every day during the 101 possible sampling days, although catches were sometimes compromised due to fowling of the traps by debris.

1996 and 1997 Capture Efficiency

The daily trap count at Caswell was expanded to estimate the daily outmigration index by dividing by the predicted daily trap efficiency (proportion of fish trapped):

$$\textit{Outmigration Index} = \frac{\textit{Count}}{\textit{Efficiency}}$$

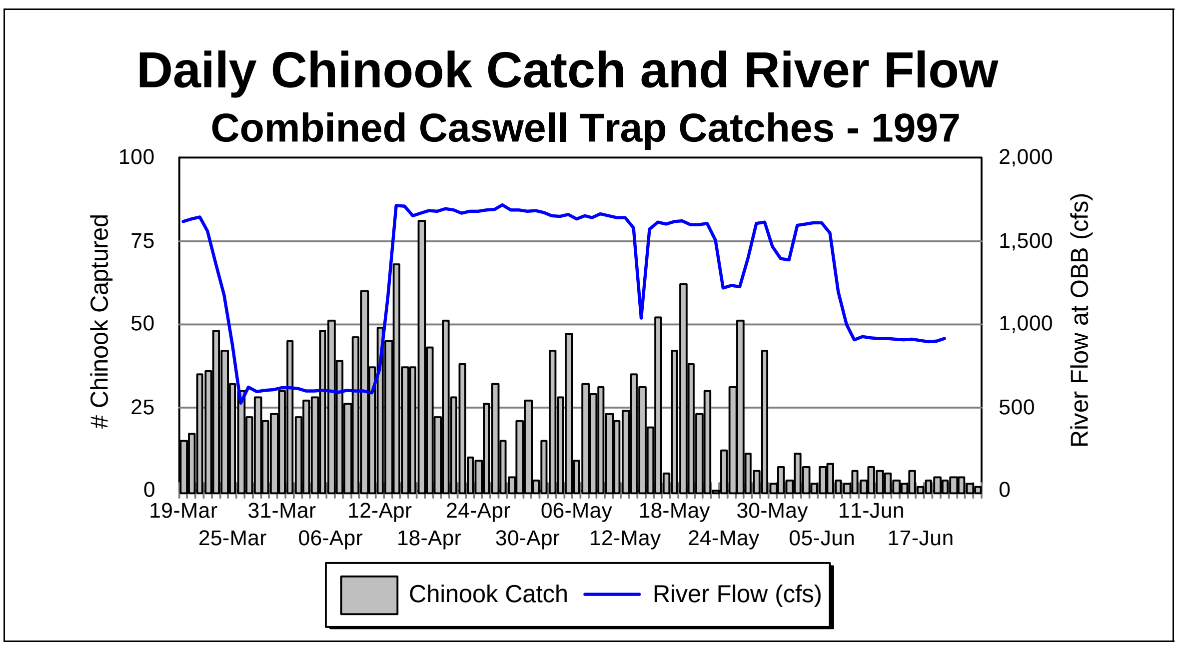
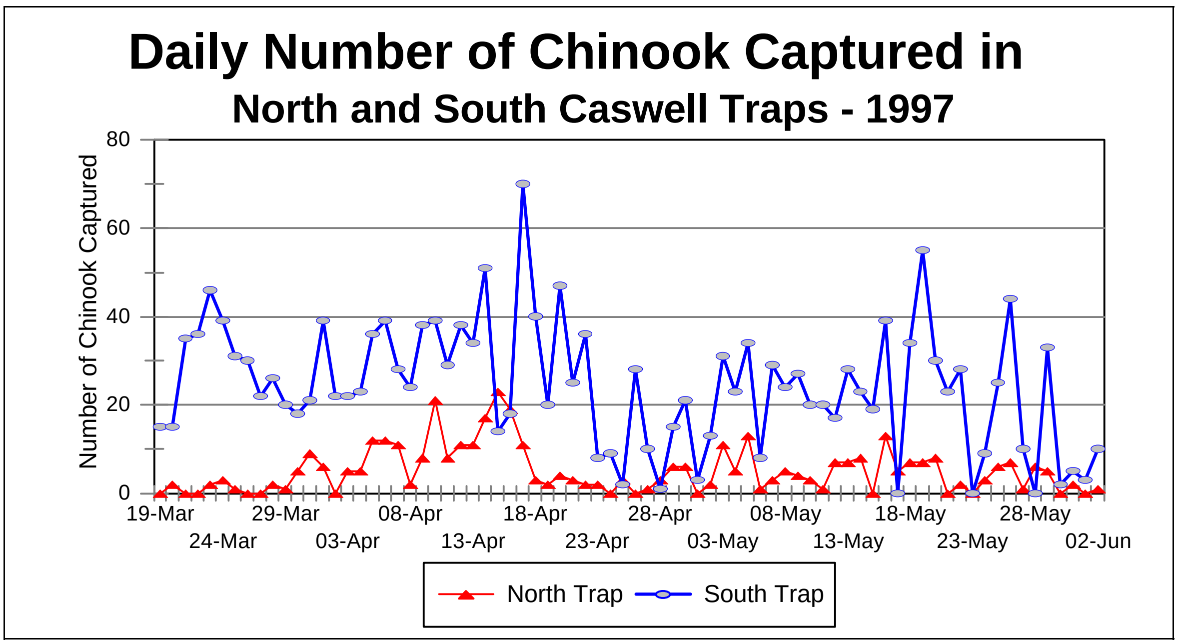


Figure 4. Total daily chinook catch from north and south traps at the Caswell site and Stanislaus River flow at OBB during 1997. All data are unexpanded for trap efficiency.

There were two screw traps operating at Caswell, one referred to as the north trap, and the other referred to as the south trap. Estimated efficiencies were simply the proportions of the released fish that were later captured in those traps. In 1996 and 1997, releases of marked fish were made a short distance upstream from the Caswell traps for the purpose of estimating their efficiencies. The releases were made in the same location, using the same release procedures, and within similar flow ranges in both years. Because of these similarities between years, we combined the data on efficiency tests for both years in order to obtain the most accurate predictor relationship for trap efficiency. Sampling



data (numbers of fish captured) were available from February 6 through July 1, 1996 and from March 19 through June 27, 1997 (hereafter referred to as passage days); whereas the efficiency estimates were only available for the 20 uniquely marked releases[1]. Combining data from the two years enabled better estimation of efficiency rates for time periods when tests were not conducted. The assumption was made that capture efficiency rates would vary similarly between years in relation to certain environmental variables.

In order to predict the efficiency for each passage day, the efficiency estimates had to be related as a response or dependent variable to predictor or independent variables that were measured on every day that the screw traps were operating. Substituting a given day's values of the predictor variables into the predictive relation would then provide an estimate of that day's efficiency. Flow and turbidity were selected to be the predictor variables, as in the past (Demko and Cramer 1997).

One assumption that is made when using this technique is that fish behave similarly throughout the sampling period. For instance, in 1996 the 1^{st} efficiency test made in February with natural fish yielded the highest recapture rates and logistic predicted efficiency. If these fish yielded a high efficiency value because they behaved differently than smolts, then this could create error in the estimating procedure. Also, improving data for all release groups, it is assumed that hatchery fish behave similarly to wild fish and similar capture rates.

The predictive relation used to relate efficiency to flow (f) measured at OBB and turbidity (t) was the logistic:

$$\mathit{Efficiency} = \frac{1}{1 + \exp(a + b_f \cdot \mathit{flow} + b_t \cdot \mathit{turbidity})}$$

---

[1] *Many of the releases represented multiple releases on the same day: The number of releases in 1996 were one on Feb 14, one on Feb 19, one on March 22, four on Apr 6, two on May 2, two on May 10, two on May 26, and two on June 10; and the number of releases in 1997 were one marked grouped release over from April 7 through 11 and four releases made on the night of May 28/29.*

or, using the "logit" transform,

$$logit\,(\,Efficiency\,) = \ln\left[\frac{Efficiency}{1 - Efficiency}\right] = -a - b_f \times flow \pm b_t \times turbidity$$

In the above equations "exp" is the exponential function, "ln" is the natural log, "a" is a coefficient associated with f = t = 0 intercepts {Efficiency = 1/[1+exp(a)] when f = t = 0}, and b_f and b_t are partial linear regression coefficients respectively relating the logit transform of efficiency to the predictor variables. The primary reason for choosing the logistic model is that the predicted efficiency can never be less than 0 (0%) and can never exceed 1 (100%). The logistic regression used assumes that the underlying distribution of the number of captured fish is binomial when the model is accurate.

The form of the model developed here is different than used in the previous analysis of 1996 data (Demko and Cramer 1997). In 1996, results were given for two separate models, one based on flow and the other based on turbidity. The model used in 1997, and reapplied to the 1996 data base, incorporates both flow and turbidity into the same model. Both flow and turbidity were retained in the model because the effect of flow when turbidity was accounted for was significant ($P < 0.01$), and the effect of turbidity when flow was accounted for was significant ($P < 0.01$), implying that using both predictor variables in a single model gives a more accurate entrainment predictor than including just one of the variables (see Appendix 1 for detailed explanation). The values of the variables used to calculate the logistic regression are presented in Table 3 along with the predicted values. The fit of predicted to observed values is displayed in Figure 5.

Table 3. Predictor variables (flow and turbidity) and response variable (actual trap efficiency estimate) used to estimate logistic model parameters for the purpose of predicting trap efficiency for 1996 and 1997. For some releases, the associated predictor variable was not measured, so the mean of the values from the two adjacent days was substituted.

Date	Flow (f) [CFS]	Turbidity (t) (NTU)	Actual Estimated Trapping Efficiency	Predicted Value [4]
14-Feb-96	1179	14.7	0.121	0.121
19-Feb-96	2014	10.5	0.055	0.031
22-Mar-96	3413	7.3	0.014	0.005
06-Apr-96	1791	5.9	0.029	0.018
06-Apr-96	1791	5.9	0.011	0.018
06-Apr-96 [1]	1791	5.9	0.000	0.018
06-Apr-96 [1]	1791	5.9	0.000	0.018
02-May-96	1680	10.2	0.076	0.040
02-May-96	1680	10.2	0.044	0.040
10-May-96	1667	8.7	0.022	0.031
10-May-96	1667	8.7	0.025	0.031
26-May-96	921	6.8	0.067	0.044
26-May-96	921	6.8	0.054	0.044
10-Jun-96	1279	8.6	0.028	0.043
10-Jun-96	1279	8.6	0.030	0.043
09-Apr-97 [2]	596	8.3	0.016	0.073
28-May-97	1608	9.8	0.027	0.039
28-May-97	1608	9.8	0.024	0.039
28-May-97	1608	9.8	0.021	0.039
28-May-97 [3]	1608	9.8	0.036	0.039

[1] Releases were day-time releases; whereas, all other releases were evening or night-time releases.

[2] Release dates were 07 Apr through 11 Apr but involved same mark so that most recoveries could not be identified by release date.

[3] Release actually made after midnight 29 Feb, but same night as previous releases, 28 Feb.

[4] 1/[1+exp(3.393+0.000895*f-0.167*t)

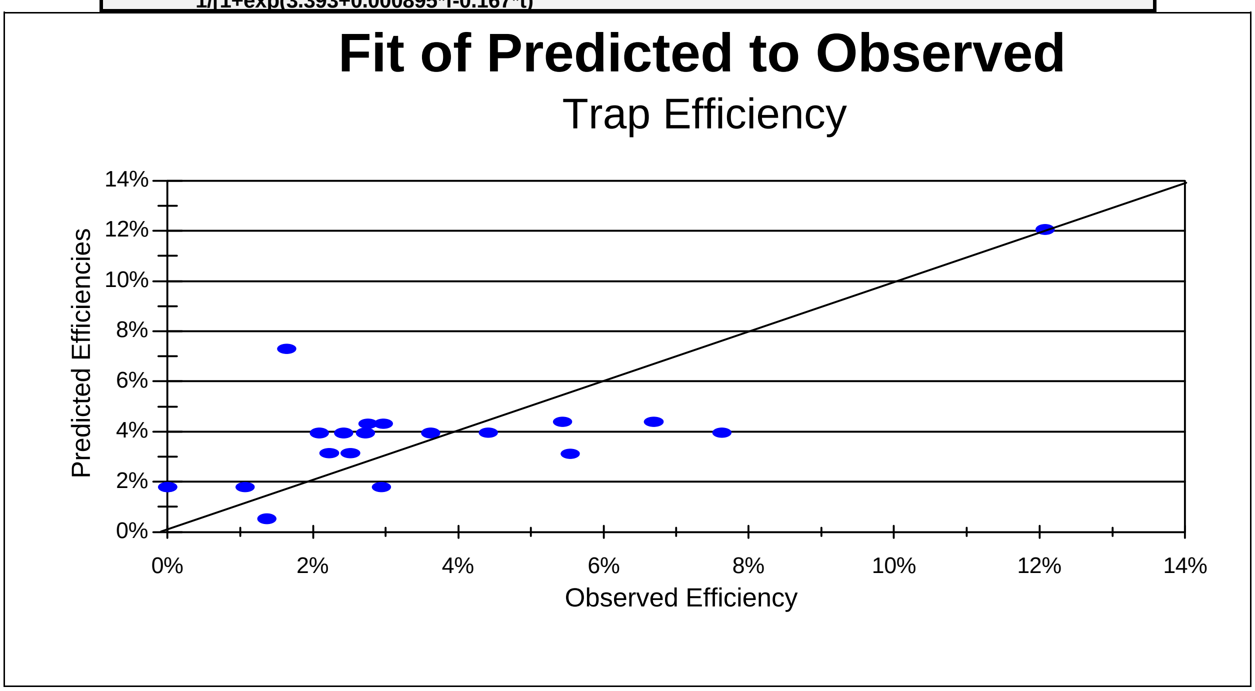


Figure 5. Fit of predicted efficiencies,1/[1 + exp(3.39344 + 0.0008946*Flow - 0.16738*Turbidity)], to the actual efficiency estimated from marked releases in 1996 and 1997.

Although the trapping efficiency was based on combined recoveries in the north and south traps, there were differences in the catches of the two traps. Based on log transformations, the number of fish caught in the north trap in 1997 was significantly less than that in the south trap (Table 4). This same tendency was found in 1996 (Demko and Cramer 1997). There was also evidence of size bias between the two traps in 1997. The mean length of fish in the north trap over the passage period was significantly greater ($P < 0.0001$) than that in the south trap, a trend that held until near the end of 1997 passage (Table 4). This is unlike the situation in 1996, when no statistically significant difference in mean lengths was found ($P = 0.34$, Demko and Cramer 1997).

Table 4. Capture number and mean lengths of fish trapped in north and south screw traps at the Caswell site in 1997.

Period		Number of Fish Caught			Mean Lengths of Fish		
Beginning Date	Ending Date	North Trap (N)	South Trap (S)	Difference in Logs ln(N)-ln(S)	North Trap (N)	South Trap (S)	Difference (N-S)
03/19/97	03/23/97	4	147	-3.604	77.3	72.4	4.9
03/24/97	03/28/97	6	148	-3.205	79.7	75.1	4.5
03/29/97	04/02/97	21	120	-1.743	82.2	77.4	4.9
04/03/97	04/07/97	45	148	-1.191	85.3	79.4	5.8
04/08/97	04/12/97	50	168	-1.212	84.6	81.4	3.2
04/13/97	04/17/97	80	166	-0.730	85.2	82.3	2.8
04/18/97	04/22/97	14	168	-2.485	87.4	83.7	3.6
04/23/97	04/27/97	10	82	-2.104	85.4	85.0	0.4
04/28/97	05/02/97	17	53	-1.137	88.4	86.7	1.7
05/03/97	05/07/97	33	125	-1.332	88.4	87.7	0.7
05/08/97	05/12/97	20	108	-1.686	88.0	87.4	0.6
05/13/97	05/17/97	33	109	-1.195	90.3	89.7	0.6
05/18/97	05/22/97	23	165	-1.970	91.9	89.2	2.7
05/23/97	05/27/97	17	87	-1.633	93.1	89.3	3.9
05/28/97	06/01/97	14	45	-1.168	91.3	90.4	0.9
06/02/97	06/06/97	3	32	-2.367	89.7	88.7	0.9
06/07/97	06/11/97	5	16	-1.163	92.6	91.2	1.4
06/12/97	06/16/97	9	13	-0.368	85.9	90.1	-4.2
06/17/97	06/21/97	2	13	-1.872	89.0	93.5	-4.5
		Mean of differences in log counts =		-1.693	Weighted[1] Mean =		2.6
		Standard Error =		0.1851	Standard Error =		0.468
		t-Ratio =		-9.15	t-Ratio =		5.56
		Probability =		<0.0001	Probability =		<0.0001

[1] Weights are harmonic means of numbers of north- and south-trap recovered fish (effective number) to account

for differences in sample numbers within and among pairs.

Even though there appears to have been a size bias between traps in 1997, there is no strong statistical indication that the combined trap catch is biased by size. For example, the size of marked fish recovered in the two traps combined was similar to the size of fish released. For each marked group, a sample of fish was taken prior to release and the mean release length was computed. A sample of recovered fish was also taken and the mean length at recovery was computed. The mean difference between average release and recovery lengths over mark groups was small (1 mm) and not statistically significant (P = 0.108) in 1996 and 1997 (Table 5). Thus, we conclude, the trap efficiency estimates at Caswell may serve to represent the efficiency for all fish passing Caswell.

Table 5. Comparisons of length (mm) of marked fish at time of release and recovery at the Caswell site, 1996 and 1997.

Release		Number Measured		Mean Length		
Date	Source	At Release	At Recapture	At Release	At Recapture	Difference
1996						
Feb 14	Natural	30	62	34.3	35.2	0.9
Feb 19	Natural	30	56	33.8	35.5	1.7
Mar 22	Hatchery	30	15	42.7	41.8	-0.9
Apr 6	Hatchery	30	22	67.4	71.6	4.2
Apr 6	Hatchery	30	8	70.2	72.9	2.7
Apr 6	Hatchery	30	-	73.2	-	-
Apr 6	Hatchery	30	-	69.7	-	-
May 2	Hatchery	30	30	76.1	76.7	0.6
May 2	Hatchery	30	30	75.5	75.9	0.4
May 10	Hatchery	30	50	74.2	73.4	-0.8
May 10	Hatchery	30	55	76.1	72.9	-3.2
May 26	Hatchery	30	60	71.7	69.9	-1.8
May 26	Hatchery	30	65	72.7	68.2	-4.5
Jun 10	Hatchery	30	43	91.6	85.5	-6.1
Jun 10	Hatchery	30	56	90.5	86.8	-3.7
1997						
Apr 9[1]	Natural	30	3	82.5	81.7	-0.8
May 28	Hatchery	30	52	71.3	71.9	0.6
May 28	Hatchery	30	35	71.9	71.5	-3.7

May 28	Hatchery	30	30	72.5	71.9	-0.6
May 28	Hatchery	30	66	73.3	72	-1.3
					weighted[2] mean difference =	1.01
					standard error =	0.594
					t-ratio (12 d.f.) =	1.7
					Probability =	0.108

\- Releases were excluded from comparison because no fish were recovered

[1] Release dates were 07 Apr through 11 Apr but involved same mark so that most recoveries could not be identified by release date

[2] Weights are harmonic means of numbers of released and recovered fish (effective number) to account for differences in sample numbers within and among pairs

1996 and 1997 Estimated Outmigrant Abundance

In order to estimate the number of chinook passing the trap site each day, we divided the combined trap catches by the trap efficiency estimated for that day:

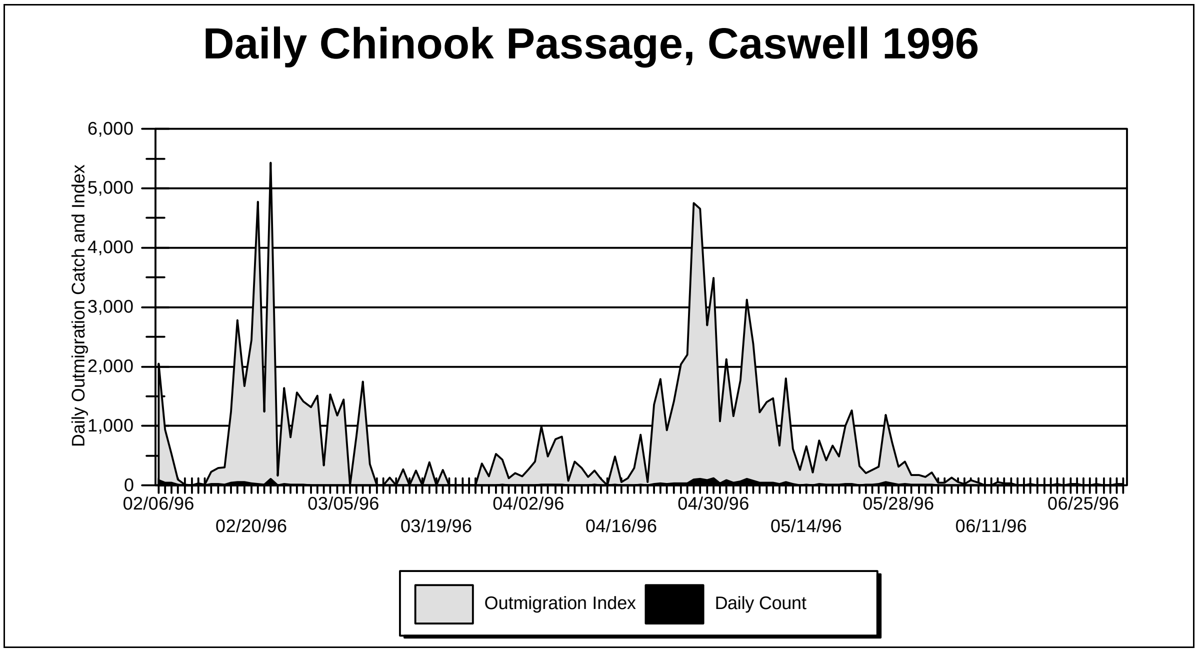
$$\mathit{Outmigration\ Index} = \frac{\mathit{Count}}{\mathit{Efficiency}} = \frac{\mathit{Count}}{\left[\dfrac{1}{1+\exp(a+b_f\cdot f+b_t\cdot t)}\right]} = \mathit{Count}\cdot[1+\exp(a+b_f\cdot f+b_t\cdot t)]$$

We term our estimate of juvenile passage to be an “outmigration index” because it does not encompass the entire outmigration, some interpolation of missing daily values was required and there are possible sources of bias that remain to be tested. Within the dates of evaluation there were passage days when flow, turbidity, and count data were not available. Methods of interpolation were developed in 1996 (Demko and Cramer 1997) to compute values of flow, turbidity, and count when missing, and these same methods were applied to the 1997 data set. One potential source of bias that has not been thoroughly tested, is our assumption that the proportion of fish passing during daylight is small and consistent. Trap efficiency is known to be lower during daylight, but trap efficiencies were estimated at night when most fish are believed to migrate downstream.

In addition to analysis of the 1997 outmigration data, we re-calculated the 1996 outmigration index, based on the revised estimate of trap efficiency. The revised 1996 passage estimates are somewhat higher than the original estimates presented in our report for the 1996 sampling (Demko and Cramer 1997). The outmigration timing did not change, only the magnitude of daily estimates. The revised daily passage estimates do not affect the overall analysis or conclusions made in the 1996 report.

The daily catches and estimated outmigration indices for chinook salmon in 1996 and 1997, are shown in Figure 6. The cumulative outmigration indices for 1996 and 1997, respectively, along with their 95% confidence limits are shown in Figure 7. The estimated February 6 through July 1, 1996 cumulative outmigration index was 105,000 with an approximate 95% confidence interval of 46,000 and 165,000. These estimates were somewhat higher than the estimates given in the previous report for 1996 (Figure 8; Demko and Cramer 1997). Since the estimates in the previous report were based either on flow alone (estimate of 78,000 ± 52,000) or on turbidity alone (estimate of 71,000 ± 29,000), instead of combined, the estimates in the 1996 report are likely to be less accurate. The March 19 through June 27, 1997 cumulative outmigration index was 47,000 with approximate 95% confidence limits of 35,000 and 59,000.

If we compare chinook passage during the same time period in 1996 and 1997, March 19 to June 27, 64,173 chinook were estimated to have passed the traps in 1996, whereas 46,920 chinook were estimated to pass the traps in 1997 (Figure 9). These differences were not statistically significant ($P > 0.05$), as can be seen from the overlap in the confidence intervals displayed in Figure 7. This time frame is appropriate for comparing outmigration of smolts (> 70 mm), because most fish emigrating before mid-March were fry in 1996. The same was probably true in 1997, as indicated by the fact we capture several fry during the first week of sampling in 1997 (see Figure 10).



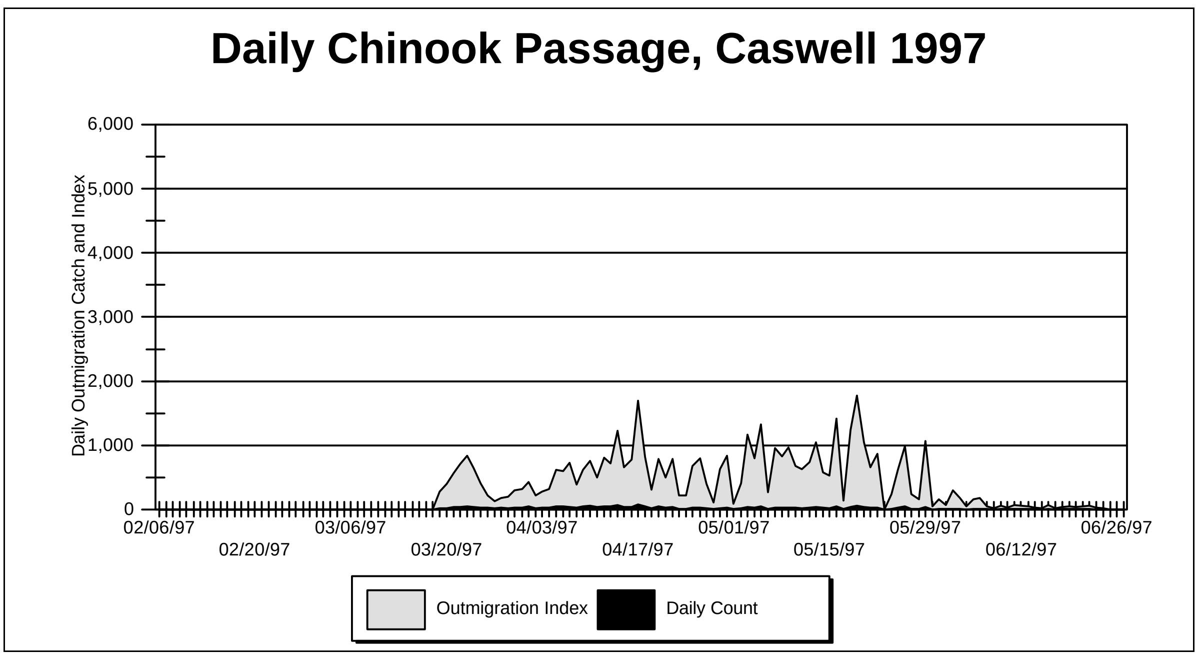
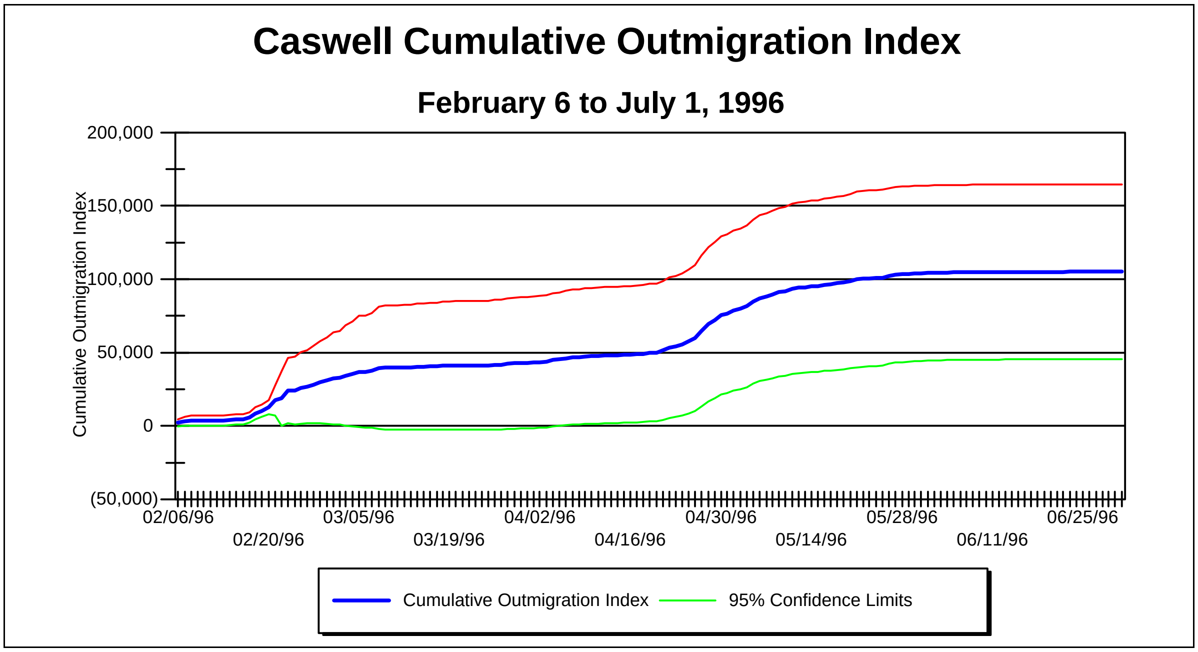


Figure 6. Daily chinook catch and passage estimates in 1996 and 1997 at the Caswell site. Data for 1996 is revised.



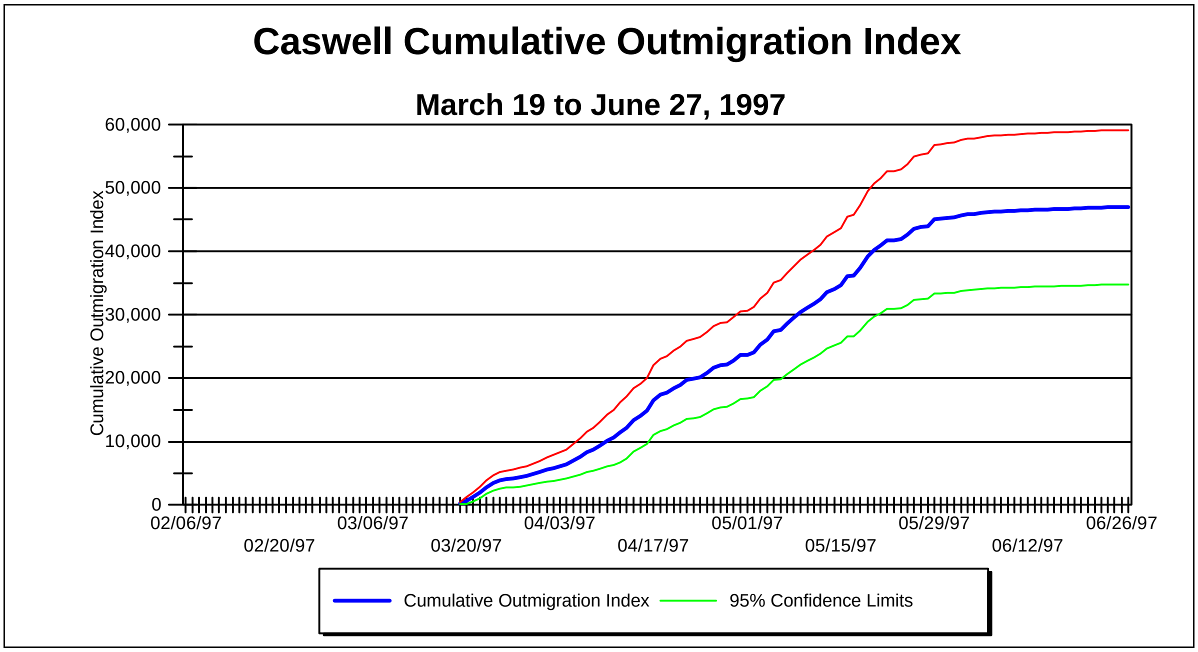


Figure 7. Estimates and 95% confidence intervals of cumulative outmigration index of juvenile chinook passing the Caswell trapping site during sampling in 1996 and 1997. Estimates for 1996 are revised.

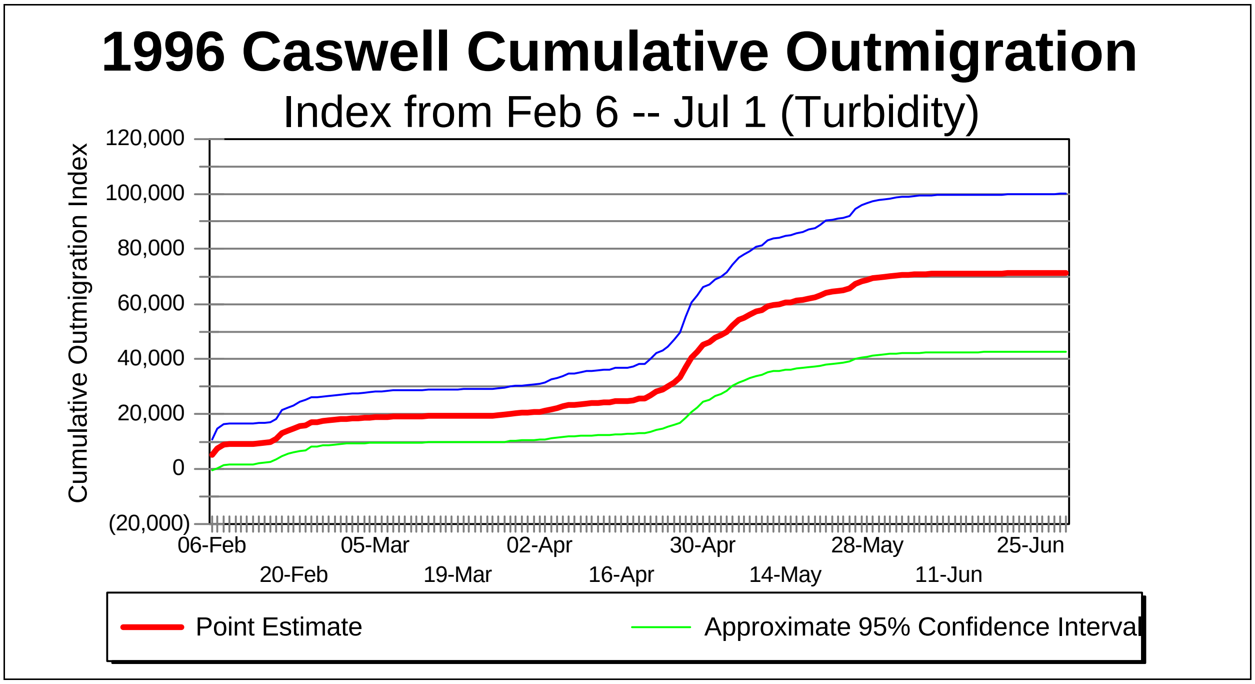


Figure 8. Original estimates and 95% confidence intervals of cumulative outmigration index of juvenile chinook passing the Caswell trapping site from February 6 through July 1, 1996. (Data is non-revised 1996 outmigration index from Demko and Cramer 1997.)

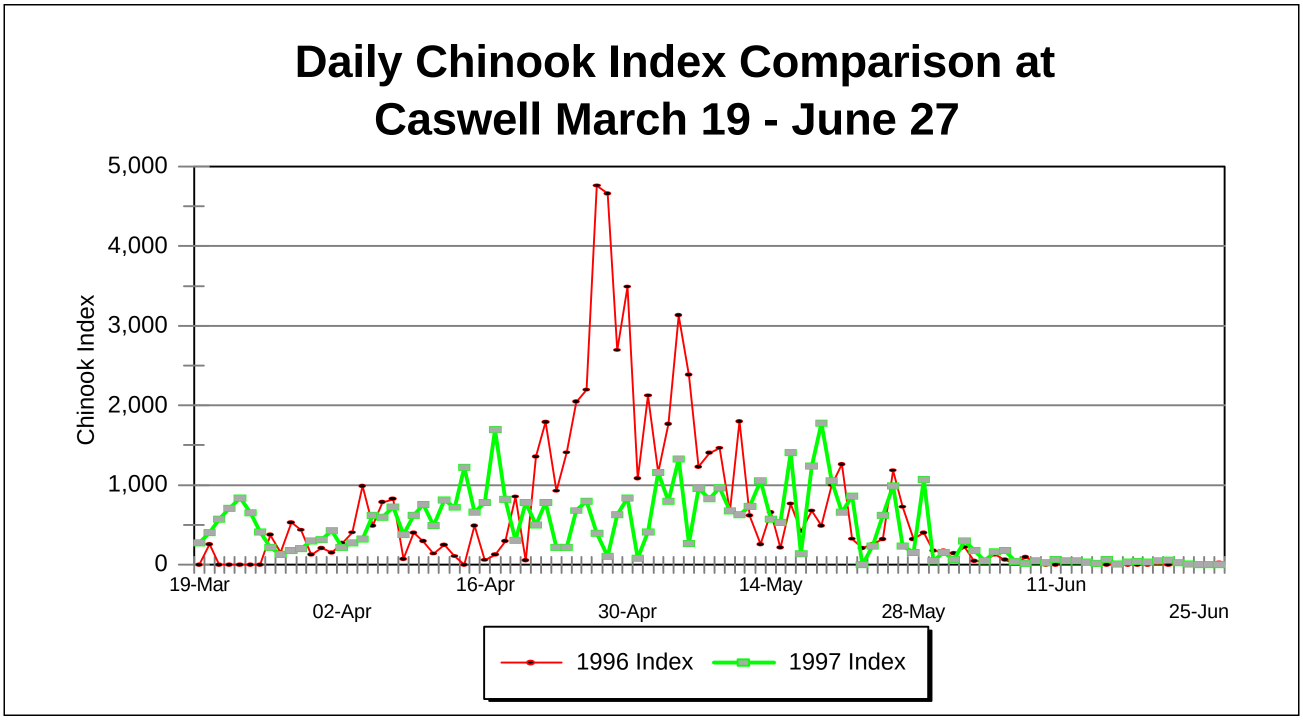


Figure 9. Daily chinook index compared for 1996 and 1997 at Caswell from March 19 to June 27. Estimates for 1996 are revised values.

The approximate confidence intervals of the 1996 cumulative outmigration index were large, encompassing impossibly negative lower limits through nearly half of the passage period (Figure 7). This is reflected in the large coefficient of variation (CV) of the estimated February 6 through July 1 cumulative outmigration index

$$CV = 100\left[\frac{SE\ (\ Estimated\ Cumulative\ Outmigration\ Index\ )}{Estimated\ Cumulative\ Outmigration\ Index}\right] = 29\%$$

The approximate confidence intervals of the 1997 cumulative outmigration index were much smaller (Figure 7), because the associated coefficient of variation of the estimated

February 6 through July 1 cumulative outmigration index was

$$CV = 100\left[\frac{SE\ (\ Estimated\ Cumulative\ Outmigration\ Index\ )}{Estimated\ Cumulative\ Outmigration\ Index}\right] = 13\%$$

The greater precision associated with the 1997 estimates relative to the 1996 estimates (narrower confidence intervals in 1997) was likely attributable to less variability in adjacent day capture counts in 1997 than in 1996. Methods of approximating standard errors (SE) used in confidence intervals are discussed in Appendix 1.

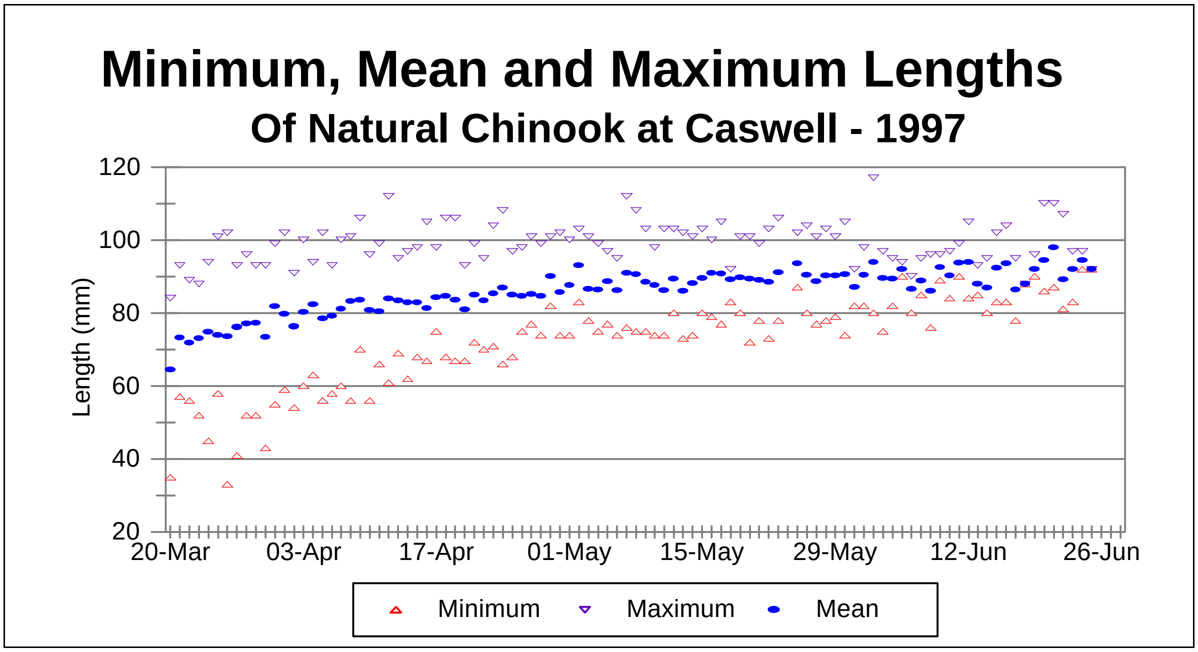
We also captured a variety of non-salmonid fishes throughout the sampling season. (Appendix 7). These fish were identified to the lowest taxonomic level that was readily distinguishable. Fish were counted and random subsamples were measured.

OBJECTIVE 2: DETERMINE THE SIZE AND SMOLTING CHARACTERISTICS OF JUVENILE CHINOOK SALMON AND RAINBOW TROUT/STEELHEAD MIGRATING OUT OF THE STANISLAUS RIVER.

Length at Outmigration

The mean lengths of juvenile chinook gradually increased over the course of sampling, ranging from around 70 mm at the start of sampling to around 95 mm in mid-June (Figure 10 and Appendix 8). The gradual increase in mean lengths over time in 1997 was similar to the pattern in 1996, except that mean lengths were slightly smaller in 1997 on the same dates (Figure 10). We did not sample early enough in 1997 to capture the main outmigration of emerging fry (< 45 mm) which typically would occur in January and February. However, we did capture several fry during our first week of sampling in 1997, which indicates that completion of emergence occurred at a similar time to 1996, when the last fry were captured the third week in March. In 1996, we saw a substantial increase in mean lengths in mid-March, when the lengths of juvenile chinook increased from about 45 mm to about 75 mm during a significant decrease in flow (Demko and Cramer 1997). In 1997, the mean lengths of chinook captured in the screw traps had already reached about 70 mm when sampling began, so the effect of flow triggering the initial movement of smolts could not be observed (Figure 11). The majority of juvenile chinook captured in 1997 were between 80 and 109 mm (Figure 12). We did not capture any yearling chinook at Caswell during 1997.

During the sampling season, we captured 11 rainbow trout/steelhead at Caswell, ranging in size from 197 to 275 mm (Figure 13).



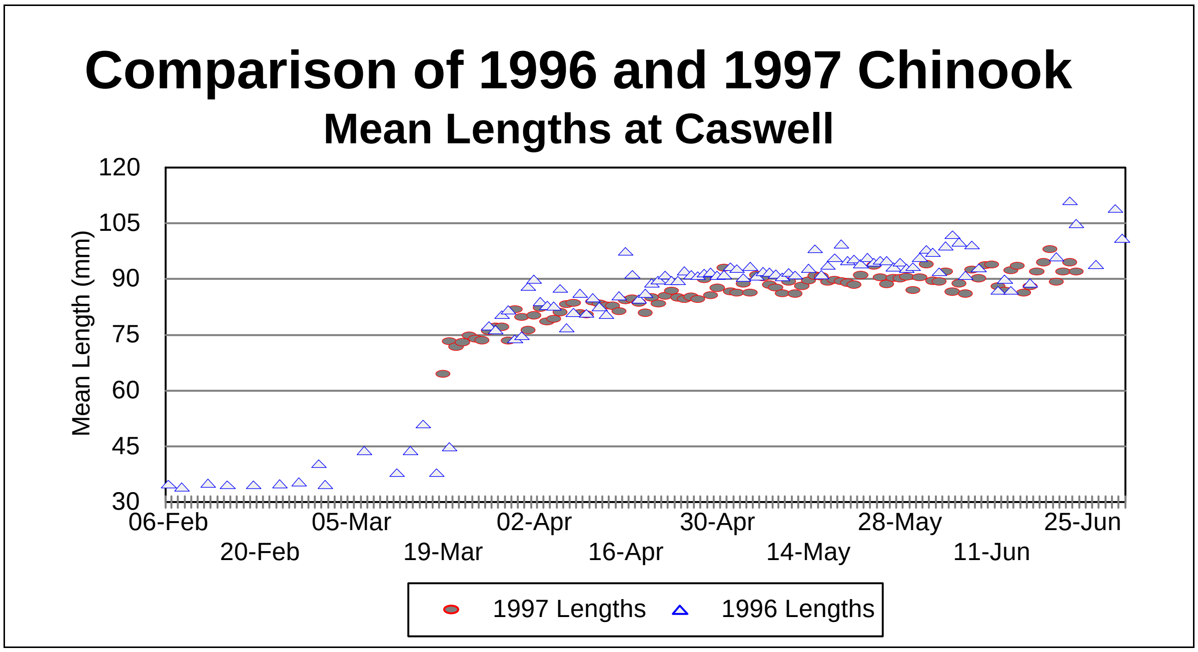
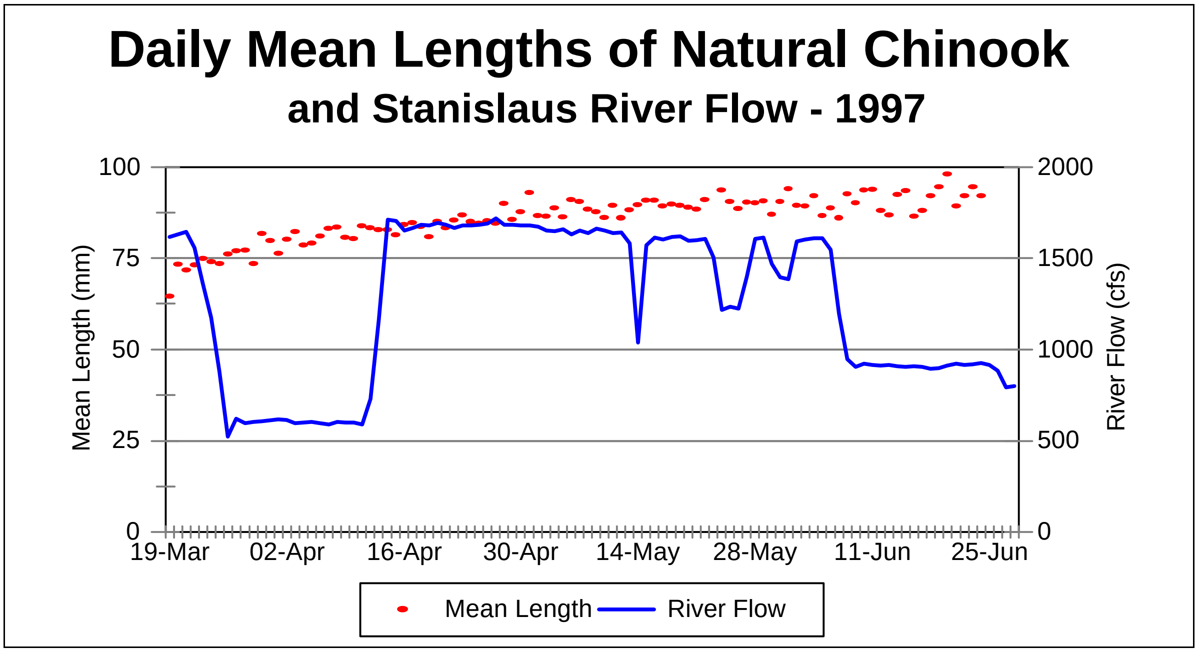


Figure 10. Minimum, mean and maximum lengths of natural chinook captured in both Caswell screw traps during 1997, and comparison of daily mean lengths at Caswell in 1996 and 1997. Mean lengths for each trap are in Appendix 8.



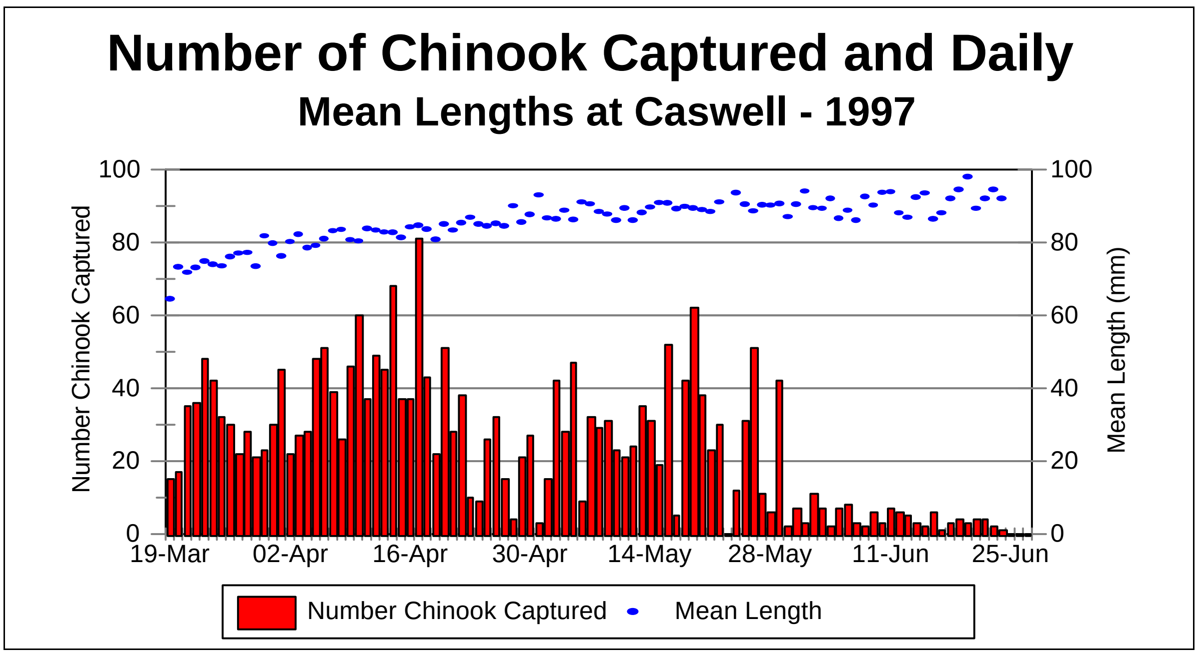
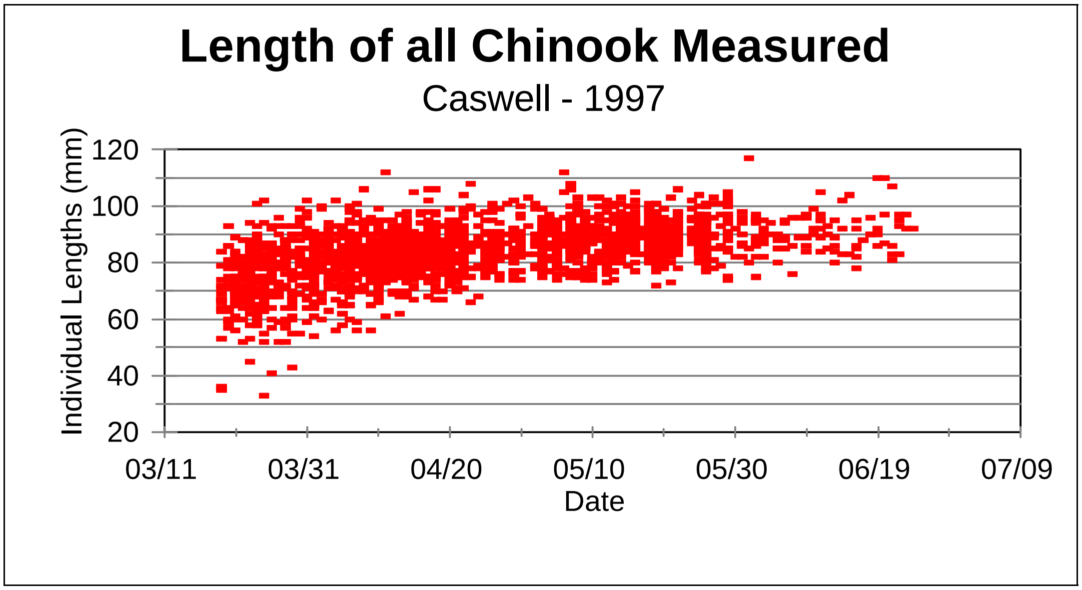


Figure 11. Daily mean lengths of natural chinook captured at Caswell and Stanislaus River flow in 1997, and number and mean lengths of chinook captured at Caswell during 1997.



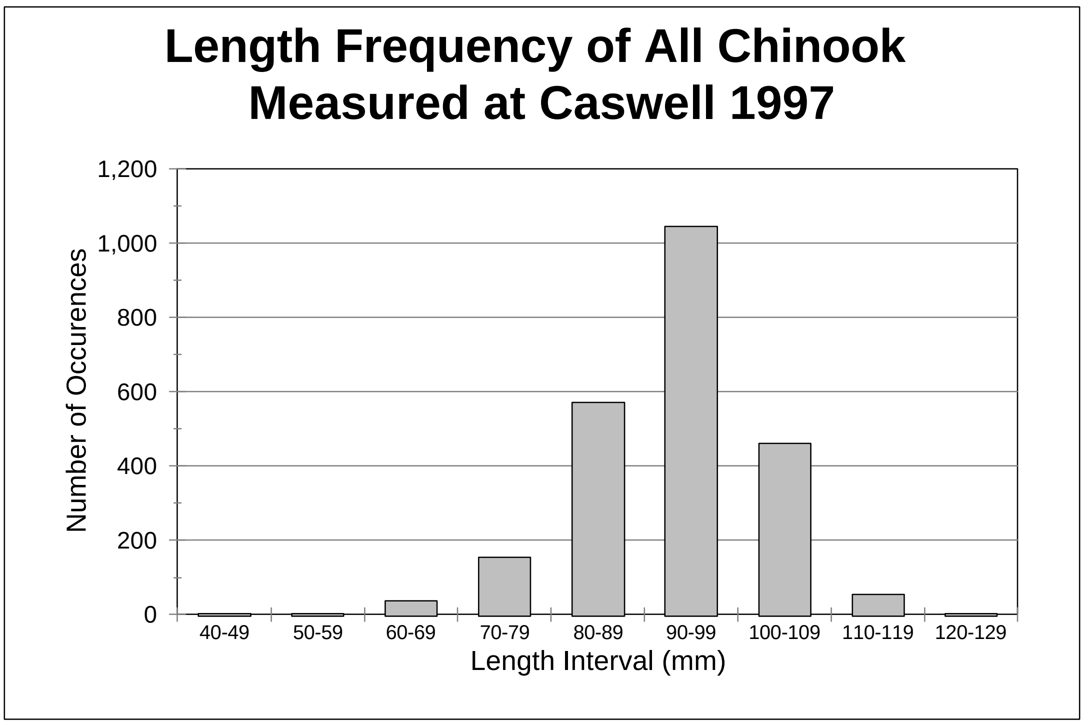


Figure 12. Scatter plot and length-frequency histogram of all chinook measured at Caswell in 1997.

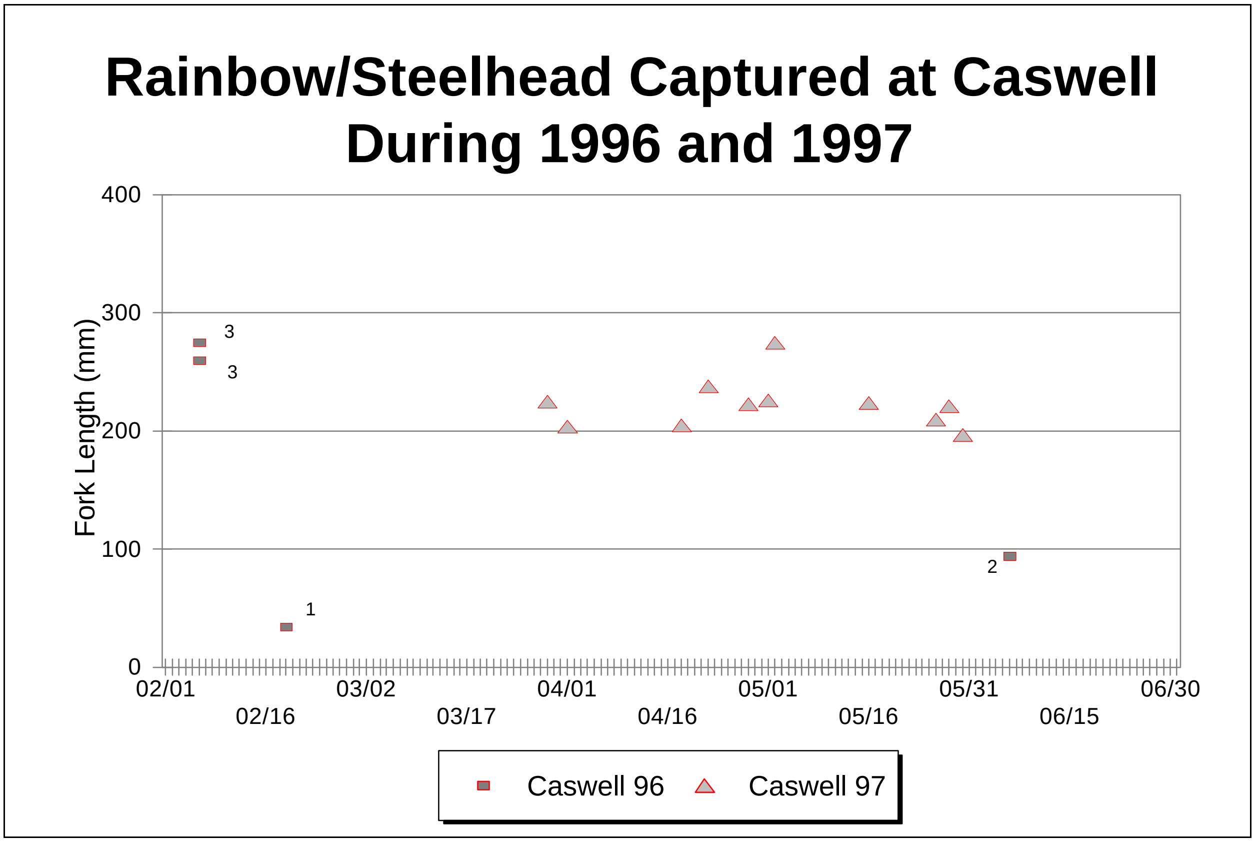


Figure 13. Fork lengths of rainbow trout/steelhead at date of capture during 1996 and 1997. Numbers next to the 1996 data points indicate the smolt appearance rating for each fish. All 1997 fish were rated as "3."

Smolt Appearance Index

The external appearance of smolt characteristics among chinook captured in the trap increased beginning in mid-April, when the mean daily value gradually increased from 2 to 3 over the next 2 months (Figure 14).

All steelhead captured in 1997 showed advanced smolting characteristics and were rated as "3's" on our smolting index. By comparison, only four rainbow trout/steelhead were captured at Caswell in 1996, two of which showed advanced smolting characteristics

(Figure 13; Appendix 9)

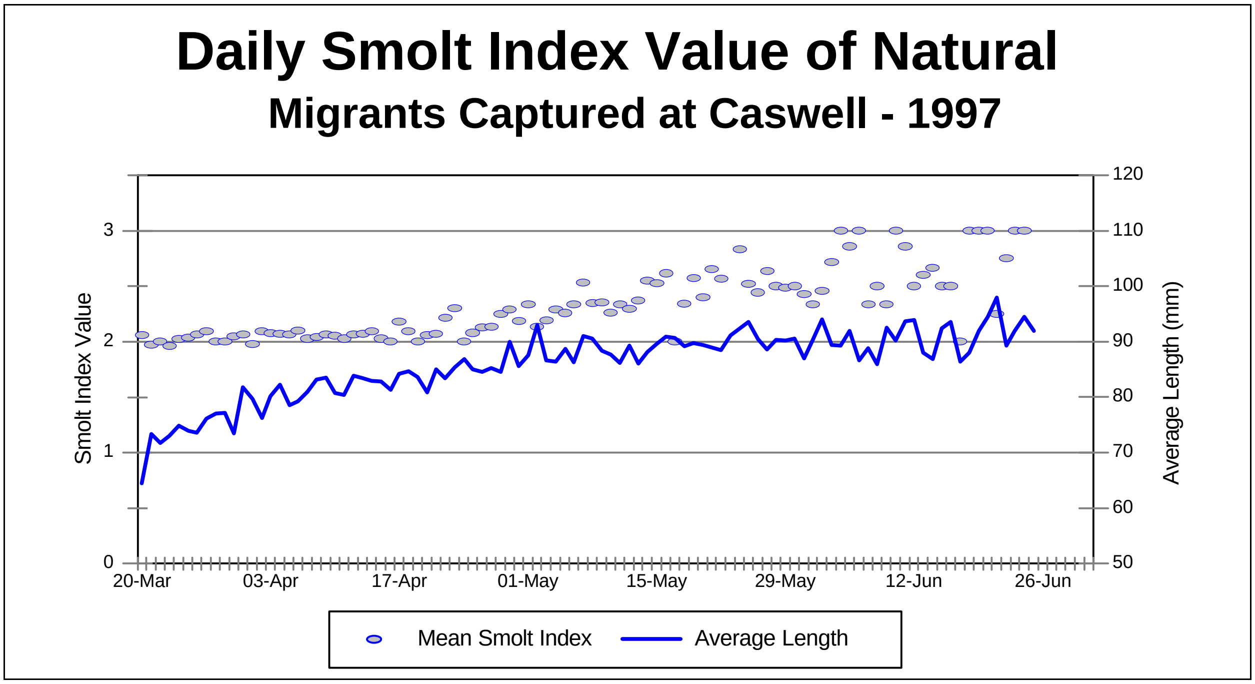


Figure 14. Mean daily smolt index value of natural chinook captured in the Caswell screw traps during 1997.

OBJECTIVE 3: IDENTIFY FACTORS THAT INFLUENCE THE TIME, SIZE AND NUMBER OF JUVENILE CHINOOK SALMON AND RAINBOW TROUT/STEELHEAD MIGRATING OUT OF THE STANISLAUS RIVER.

Effect of Streamflow on Chinook Salmon Outmigration

Although passage estimates fluctuated substantially between days, there was not a distinctive peak in passage for the season (Figure 15), as we observed in previous years. The pattern of outmigration in 1997 showed only a weak relationship to changes in streamflow; however, streamflow was nearly constant from mid-April to mid-May when most juveniles over 80 mm emigrated. The sharp drop in flow in late March coincided with an increase in passage, the sharp increase in flow during mid-April was followed by only two days with increased passage, and the drop-and-increase in flow during mid-May was followed by a few days of elevated passage (Figure 15). The number of chinook passing Caswell decreased in late May, and few chinook migrated out in June.

It is likely that, a significant number of fry migrated out during January and February 1997, similar to 1996. River flow and turbidity were unusually high in January and February 1997, and significant numbers of fry probably outmigrated before the traps were installed. Outmigrant abundance was distinctly bimodal in 1996, corresponding to peaks in fry and smolt outmigration, but fry emergence was essentially complete when sampling began in 1997.

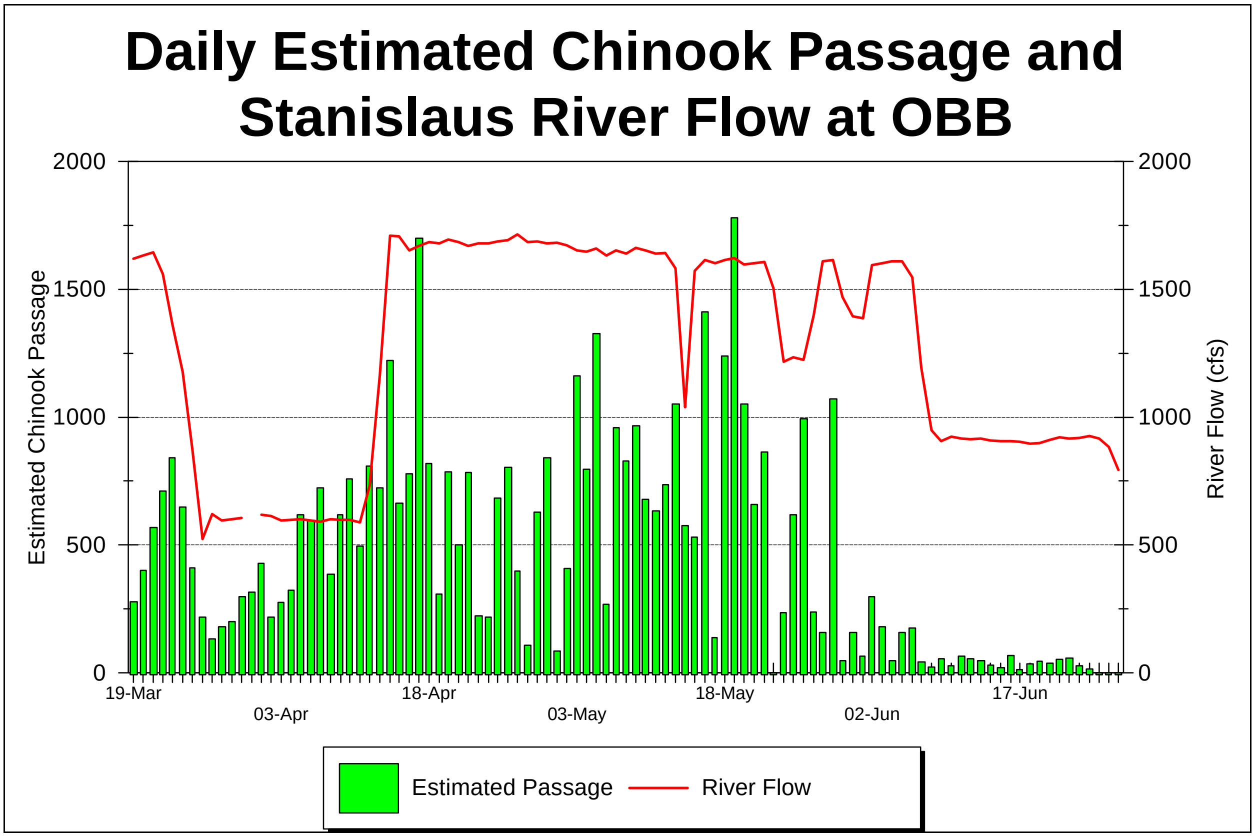
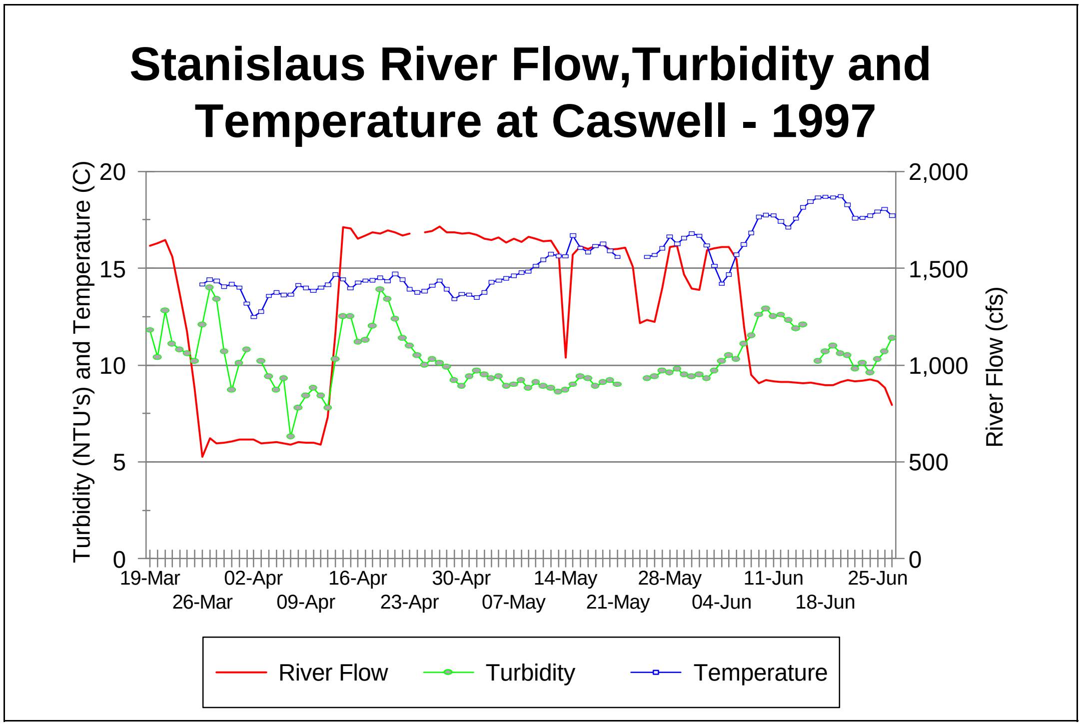


Figure 15. Daily estimated downstream passage of juvenile chinook at Caswell and Stanislaus River flow at OBB.

Effect of Turbidity and Temperature on Chinook Salmon Outmigration

Turbidity fluctuated between roughly 6 and 14 NTU's, with the highest turbidity levels occurring in March and April, coincident to significant changes in flow (Figure 16 and Appendix 4). There was only a minor and brief increase in chinook passage associated with the sharp increase in turbidity during mid-April. Turbidity was stable near its lowest value through the entire month of May, so its influence could not be observed then.



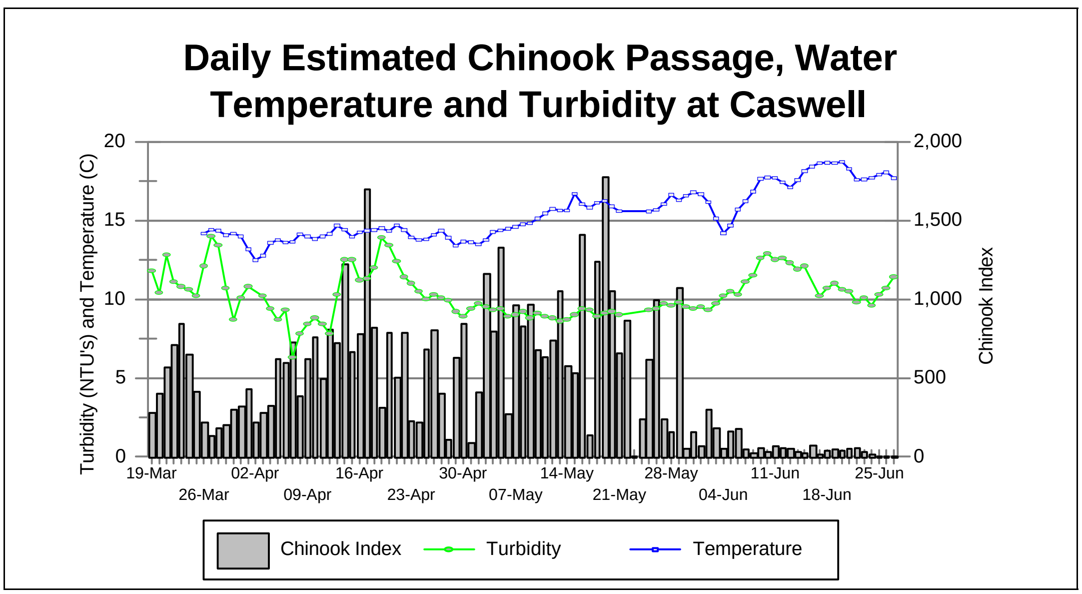


Figure 16. Daily estimated juvenile chinook passage at Caswell, in relation to river flow, temperature and turbidity; 1997.

Daily mean river temperature at Caswell increased slowly and steadily from about

12E C in late March to about 18E C at the end of June (Figure 16). There was no apparent increase in migration in relation to changes in water temperature at Caswell. However, in 1996, also a high flow year, we did see an increase in smolt passage at Caswell as temperatures upstream at Oakdale reached approximately 10E C (Demko and Cramer 1997). There was no sampling at Oakdale in 1997, so no water temperature recorder was placed at, or upstream from Oakdale.

CONCLUSIONS

1. The estimated number of juvenile chinook that passed Caswell between March 19 and June 27, 1997, was 47,000, with approximate 95% confidence intervals of 35,000 and 59,000.

2. The majority of chinook captured at Caswell during 1997 were smolts between 80 and 99 mm. Sampling began after the emergence of fry was nearly complete, so the abundance of outmigrating fry was not estimated. An index of total outmigrant abundance could therefore not be estimated for 1997.

3. There was no distinct peak in outmigration of chinook in 1997. The daily outmigration index remained between 500 and 1,000 chinook for much of April and May, and few chinook outmigrated after the end of May.

4. Mean lengths of juvenile chinook gradually increased over the course of sampling, ranging from around 70 mm at the start to 95 mm in mid-June. Mean lengths in 1997 were slightly smaller than on the same date in 1996.

5. Based on a reevaluation of the 1996 Caswell data, we estimate that between February 6 and July 1, 1996, the cumulative outmigration of juvenile chinook salmon was 105,000 with an approximate 95% confidence interval of 46,000 and 165,000. These estimates are higher than the estimates presented in last year's report (71,000 with approximate 95% confidence intervals of 43,000 and 100,000).

6. The original chinook passage estimate at the Caswell site (RM 8.6) in 1996 was only 25% of that estimated at the Oakdale site (RM 40), for the same time period.

The revised passage estimate (105,000 versus 71,000) is 37% of the Oakdale estimate, somewhat higher than the original estimate. The difference in estimated passage still indicates that there may be substantial mortality of juvenile chinook in the 34 miles between the Oakdale and Caswell sites.

7. Small numbers of rainbow trout/steelhead showing advanced smolting characteristics were collected in both 1996 and 1997, indicating the potential presence of an anadromous run in the Stanislaus River.

RECOMMENDATIONS

1. Monitoring of juvenile salmonid outmigration should continue annually at both the Oakdale and Caswell sites, to monitor long-term trends in juvenile production in the Stanislaus River.

2. Measures should be taken to increase sampling efficiency. We believe this can best be accomplished by installing berms that divert more flow into the traps. Higher efficiencies will reduce the number of marked fish needed to conduct trap efficiency tests and therefore will allow for additional tests under more environmental conditions. Higher efficiencies will also increase the number of fish recaptured from releases made at Oakdale and Knights Ferry, allowing for better estimation of migration rates and survival from the upper to the lower river.

3. Factors contributing to the low observed survival of juvenile chinook in 1996 in the 34-mile reach between the Oakdale and Caswell sites should be investigated. Low survival was estimated in 1996 even when flows were the highest that have occurred in the Stanislaus River for many years. Estimates of juvenile passage at the two sites shold be compared again in additional years. Radio tagging and tracking of juveniles would provide the most timely reconnaissance data on location and timing of juvenile mortality between the Oakdale and Caswell sites.

4. Sampling should be initiated in early January to cover the entire period of fall-run chinook outmigration. This would comply with standard protocol specified for rotary-screw trapping in the CVPIA Comprehensive Assessment and Monitoring Program (CAMP)(August, 1997).

5. Temperature recorders should be installed at regular intervals upstream from

Caswell to further evaluate the effect of river temperature on the timing of chinook migration. We recommend installing a recorder every 5 miles from Goodwin Dam to Oakdale, then every 10 miles from Oakdale to Caswell.

6. Tests should be designed and conducted to estimate the proportion of juvenile chinook that migrate during the day throughout the emigration season.

REFERENCES

Demko, D.B. and S.P. Cramer. 1997. Effects of pulse flows on juvenile chinook migration in the Stanislaus River. Annual Report for 1996. Prepared by S.P. Cramer & Associates, Inc. for Oakdale Irrigation District, Oakdale, CA, and South San Joaquin Irrigation District, Manteca, CA.

Hart, P.J.B. and T.J. Pitcher. 1969. Field trials of fish marking using jet inoculator. J. Fish Biol. 1;383-385.

Schoettger, R.A. and E.W. Steucke. 1970. Synergic mixtures of MS-222 and quinaldine as anesthetics for rainbow trout and northern pike. The Progressive Fish-Culturist. Oct. 1970:202-205

LIST OF APPENDICES

Appendix 1. Statistical review of 1996 and 1997 Caswell screw trapping data.

Estimated 1997 Trapping Efficiency and Fish Outmigration Index at Caswell

Prepared by

Doug Neeley

Statistical Consultant

International Statistical Training and Technical Services

Oregon City, Oregon

The daily trap count at Caswell was expanded by dividing by the predicted daily trapping efficiency (proportion of fish trapped) to estimate the daily outmigration index:

$$Outmigration \quad Index = \frac{Count}{Efficiency}$$

Predicting 1996 Trapping Efficiency

There were two screw traps operating at Caswell, one referred to as the north trap, and the other referred to as the south trap. In 1996 and 1997, releases were made a short distance upriver from the Caswell traps for the purpose of estimating their trapping efficiencies. Estimated efficiencies were simply the proportions of the released fish that were later captured in those traps. Count data were available from February 6 through July 1, 1996 and from March 19 through June 27, 1997 (hereafter referred to as passage days); whereas the efficiency estimates were only available for 20 uniquely marked releases[2]. In order to predict the efficiency for each passage day, the efficiency estimates had to be related as a response or "dependent" variable to predictor or "independent" variables that were measured on every day that the screw traps were operating. Substituting a given day's values of the predictor variables into the predictive relation would then provide an estimate of that day's efficiency. For reasons discussed in the 1996 report (Cramer et al, 1997), flow and turbidity were selected to be the predictor variables.

The predictive relation used to relate efficiency to flow (f) measured at Orange Blossom Bridge (OBB) and turbidity (t) was the logistic:

$$Efficiency = \frac{1}{1 + \exp(a + b_f \cdot f + b_t \cdot t)}$$

or, using the "logit" transform,

$$logit\ (\ Efficiency\ ) = \ln[\frac{Efficiency}{1 - Efficiency}] = -a - b_f \cdot f - b_t \cdot t$$

In the above equations "exp" is the exponential function, "ln" is the natural log, "a" is a coefficient associated with f = t = 0 intercepts {Efficiency = 1/[1+exp(a)] when f = t = 0}, and b_f and b_t are partial linear regression coefficients respectively relating the logit transform of efficiency to the predictor variables. A major reason for choosing the logistic model is that the predicted efficiency can never be less than 0 and can never exceed 1 (100%). The logistic regression used assumes that the underlying distribution of the number of captured fish is binomial when the model is accurate.

---

2 *Many of the releases represented multiple releases on the same day: The number of releases in 1996 were one on Feb 14, one on Feb 19, one on March 22, four on Apr 6, two on May 2, two on May 10, two on May 26, and two on June 10; and the number of releases in 1997 were one marked grouped release over from April 7 through 11 and four releases made on the night of May 28/29.*

The form of the model is different than given in 1996. In 1996 results were given for two separate models, one based on flow and the other based on turbidity. The model used in 1997, and reapplied to the 1996 data base, incorporates both flow and turbidity into the same model. This was done because the effect of flow when turbidity was accounted for was significant, and the effect of turbidity when flow was accounted for was significant, implying that using both predictor variables in a single model gives a more accurate entrainment predictor than including just one the variables (Appendix A.1).

The coefficient estimates were

$$a = 3.393$$
$$b_f = 0.0008946$$
$$b_t = -0.1674$$

The values of the variables used in the logistic regression are presented in Table A.1 along with the predicted values. For some releases the associated predictor variable wasn't measured, in which case the mean of the values from the two adjacent days was substituted.

Table A.1. Predictor variables (flow and turbidity) and response variable (actual estimated trapping efficiency) used to estimate logistic model parameters for the purpose of predicting efficiency.

Date	Flow (f) [CFS]	Turbidity (t) (NTU)	Actual Estimated Trapping Efficiency	Predicted Value[4]
14-Feb-96	1179	14.7	0.121	0.121
19-Feb-96	2014	10.5	0.055	0.031
22-Mar-96	3413	7.3	0.014	0.005
06-Apr-96	1791	5.9	0.029	0.018
06-Apr-96	1791	5.9	0.011	0.018
06-Apr-96 [1]	1791	5.9	0.000	0.018
06-Apr-96 [1]	1791	5.9	0.000	0.018
02-May-96	1680	10.2	0.076	0.040
02-May-96	1680	10.2	0.044	0.040
10-May-96	1667	8.7	0.022	0.031
10-May-96	1667	8.7	0.025	0.031
26-May-96	921	6.8	0.067	0.044
26-May-96	921	6.8	0.054	0.044
10-Jun-96	1279	8.6	0.028	0.043
10-Jun-96	1279	8.6	0.030	0.043
09-Apr-97 [2]	596	8.3	0.016	0.073
28-May-97	1608	9.8	0.027	0.039
28-May-97	1608	9.8	0.024	0.039
28-May-97	1608	9.8	0.021	0.039
28-May-97 [3]	1608	9.8	0.036	0.039

1 Releases were day-time releases; whereas, all other releases were evening or night-time releases.

2 Release dates were 07 Apr through 11 Apr but involved same mark so that most recoveries could not be identified by release date.

3 Release actually made after midnight 29 Feb, but same night as previous releases, 28 Feb.

4 1/[1+exp(3.393+0.000895*f-0.167*t)

The trapping efficiency was based on combined recoveries over the north and south trap. Based on log transformations, the number of fish caught in the north trap was significantly less than that in the south trap (Table A.2). This same tendency held in 1996 (Cramer et al, 1997). There was also evidence of size bias between the two traps in 1997. The mean length at the north trap over the passage period was significantly greater ($P < 0.0001$) than that of the south trap, a trend that held until near the end of 1997 passage (Table A.2). This is unlike the situation in 1996 when there was no statistically significant difference in mean lengths (P = 0.34, Cramer et al, 1997).

Table A.2. Capture number and mean lengths of fish trapped in north and south screw traps at Caswell, 1997.

Period		Number of Fish Caught			Mean Lengths of Fish		
Beginning Date	Ending Date	North Trap (N)	South Trap (S)	Difference in Logs ln(N)-ln(S)	North Trap (N)	South Trap (S)	Difference (N-S)
03/19/97	03/23/97	4	147	-3.604	77.3	72.4	4.9
03/24/97	03/28/97	6	148	-3.205	79.7	75.1	4.5
03/29/97	04/02/97	21	120	-1.743	82.2	77.4	4.9
04/03/97	04/07/97	45	148	-1.191	85.3	79.4	5.8
04/08/97	04/12/97	50	168	-1.212	84.6	81.4	3.2
04/13/97	04/17/97	80	166	-0.730	85.2	82.3	2.8
04/18/97	04/22/97	14	168	-2.485	87.4	83.7	3.6
04/23/97	04/27/97	10	82	-2.104	85.4	85.0	0.4
04/28/97	05/02/97	17	53	-1.137	88.4	86.7	1.7
05/03/97	05/07/97	33	125	-1.332	88.4	87.7	0.7
05/08/97	05/12/97	20	108	-1.686	88.0	87.4	0.6
05/13/97	05/17/97	33	109	-1.195	90.3	89.7	0.6
05/18/97	05/22/97	23	165	-1.970	91.9	89.2	2.7
05/23/97	05/27/97	17	87	-1.633	93.1	89.3	3.9
05/28/97	06/01/97	14	45	-1.168	91.3	90.4	0.9
06/02/97	06/06/97	3	32	-2.367	89.7	88.7	0.9
06/07/97	06/11/97	5	16	-1.163	92.6	91.2	1.4
06/12/97	06/16/97	9	13	-0.368	85.9	90.1	-4.2
06/17/97	06/21/97	2	13	-1.872	89.0	93.5	-4.5
			Mean of differences in log counts =	-1.693		Weighted[1] Mean =	2.60
			Standard Error =	0.1851		Standard Error =	0.468
			t-Ratio =	-9.15		t-Ratio =	5.56
			Probability =	<0.0001		Probability =	<0.0001

[1] Weights are harmonic means of numbers of north- and south-trap recovered fish (effective number) to account for differences in sample numbers within and among pairs.

Even though there appears to have been a size bias between traps in 1997, there is no strong statistical indication that the combined trap catch is biased in terms of size. For each marked group, a sample of fish was taken prior to release and the mean release length computed, and a sample of recovered fish was also taken and the mean length recovery length was computed. The mean difference between release and recovery average lengths over marks (Table A.3) was small (1 mm) and not statistically significant ($P = 0.108$) over 1996 and 1997.

Table A.3. Comparisons in lengths (mm) of fish at times of release and recovery (Caswell, 1996).

		Number Measured		Mean Length		
Release Date	Source	At Release	At Recapture	At Release	At Recapture	Difference
1996						
Feb 14	Natural	30	62	34.3	35.2	0.9
Feb 19	Natural	30	56	33.8	35.5	1.7
Mar 22	Hatchery	30	15	42.7	41.8	-0.9
Apr 6	Hatchery	30	22	67.4	71.6	4.2
Apr 6	Hatchery	30	8	70.2	72.9	2.7
Apr 6	Hatchery	30	-	73.2	-	-
Apr 6	Hatchery	30	-	69.7	-	-
May 2	Hatchery	30	30	76.1	76.7	0.6
May 2	Hatchery	30	30	75.5	75.9	0.4
May 10	Hatchery	30	50	74.2	73.4	-0.8
May 10	Hatchery	30	55	76.1	72.9	-3.2
May 26	Hatchery	30	60	71.7	69.9	-1.8
May 26	Hatchery	30	65	72.7	68.2	-4.5
Jun 10	Hatchery	30	43	91.6	85.5	-6.1
Jun 10	Hatchery	30	56	90.5	86.8	-3.7
1997						
Apr 9[1]	Natural	30	3	82.5	81.7	-0.8
May 28 11:10	Hatchery	30	52	71.3	71.9	0.6
May 28 11:10	Hatchery	30	35	71.9	71.5	-3.7
May 28 11:10	Hatchery	30	30	72.5	71.9	-0.6
May 28 11:10	Hatchery	30	66	73.3	72	-1.3
					weighted[2] mean difference =	1.01
					standard error =	0.594
					t-ratio (12 d.f.) =	1.7
					Probability =	0.108

\- Releases were excluded from comparison because no fish were recovered

[1] Release dates were 07 Apr through 11 Apr but involved same mark so that most recoveries could not be identified by release date

[2] Weights are harmonic means of numbers of released and recovered fish (effective number) to account for differences in sample numbers within and among pairs

With no strong indication of size bias, the trapping efficiency estimates at Caswell may serve to represent the efficiency for all fish passing Caswell. The trapping-efficiency prediction equation is given in Figure A.1 along with the release days' predicted efficiencies and the actual efficiency estimates. The weighted correlation between the predicted and the actual estimated efficiencies was 0.77, the weighting variable being the number of fish released.

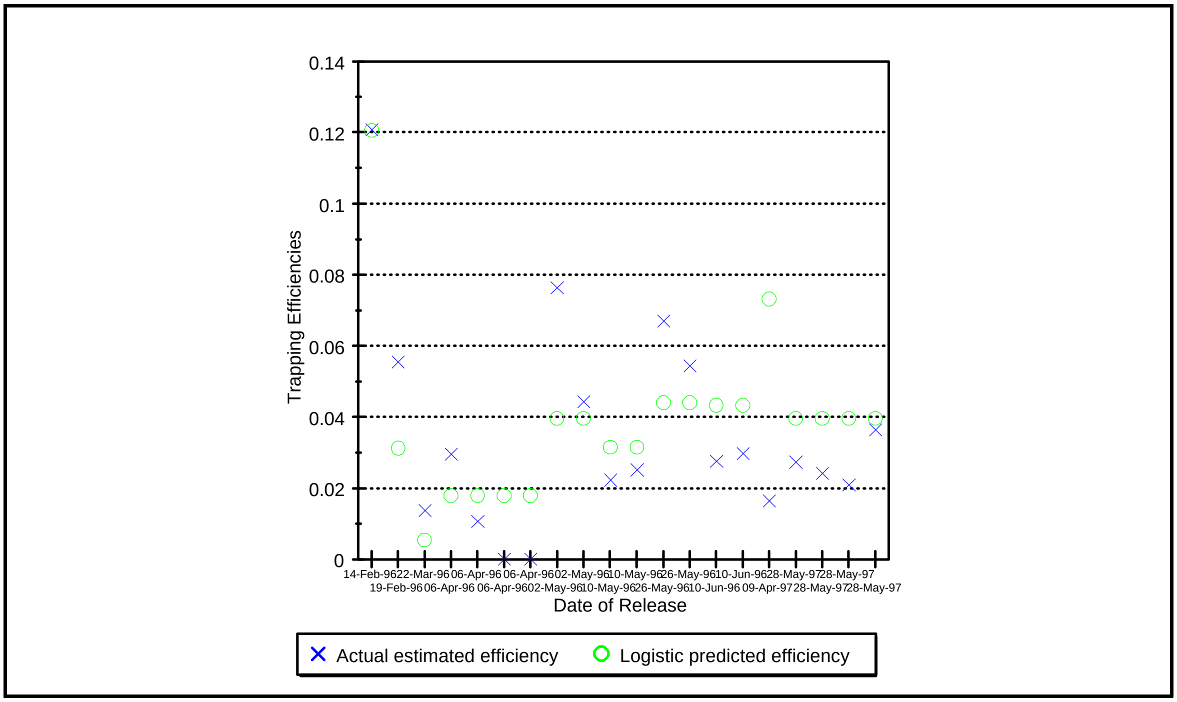


Figure A.1. Actual efficiency estimates and predicted efficiencies, 1/[1 + exp(3.39344 + 0.0008946*Flow - 0.16738*Turbidity)], based on marked releases in 1996 and 1997.

Outmigration Index Estimation

Substituting the efficiency-to-flow predictor into the outmigration index estimation equation gives:

$$\mathit{Outmigration\ Index} = \frac{\mathit{Count}}{\mathit{Efficiency}} = \frac{\mathit{Count}}{\left[\frac{1}{1+\exp(a+b_f \cdot f+b_t \cdot t)}\right]} = \mathit{Count}\cdot[1+\exp(a+b_f \cdot f+b_t \cdot t)]$$

Within the dates of evaluation there were passage days when flow, turbidity, and count data were not available. Methods of interpolation were developed in 1996 (Cramer et al, 1997) to compute values of flow, turbidity, and count when missing, and these same methods were applied to the 1997 data set. Interpolated values were needed to estimate the cumulative outmigration index.

Outmigration Indices

The outmigration indices and counts for 1996 and 1997 are respectively given in Figures A.2.a and A.2.b. The cumulative outmigration indices for 1996 and 1997 along with their 95% confidence limits are respectively given in Figures A.3a and A.3.b. The estimated February 6 through July 1, 1996 cumulative outmigration index was 105,000 with an approximate 95% confidence interval of 46,000 and 165,000. These estimates were somewhat higher than the estimates given in the 1996 report (Cramer et al, 1997). Since the estimates in the 1996 report were based either on flow alone (estimate of 78 ± 52,000) or on turbidity alone (estimate of 71 ± 29,000), instead of both together, the estimates in the 1996 report are likely to be less accurate. The March 19 through June 27, 1997 cumulative outmigration index was 47 ,000 with approximate 95% confidence limits of 35,000 and 59,000, indicating that the passage index in 1997 was less than that in 1996. It is possible that the shorter passage interval evaluated in 1997 (March 19 through June 27) compared to 1996 (February 6 to July 1) partially contributed to the smaller passage estimate in 1997.

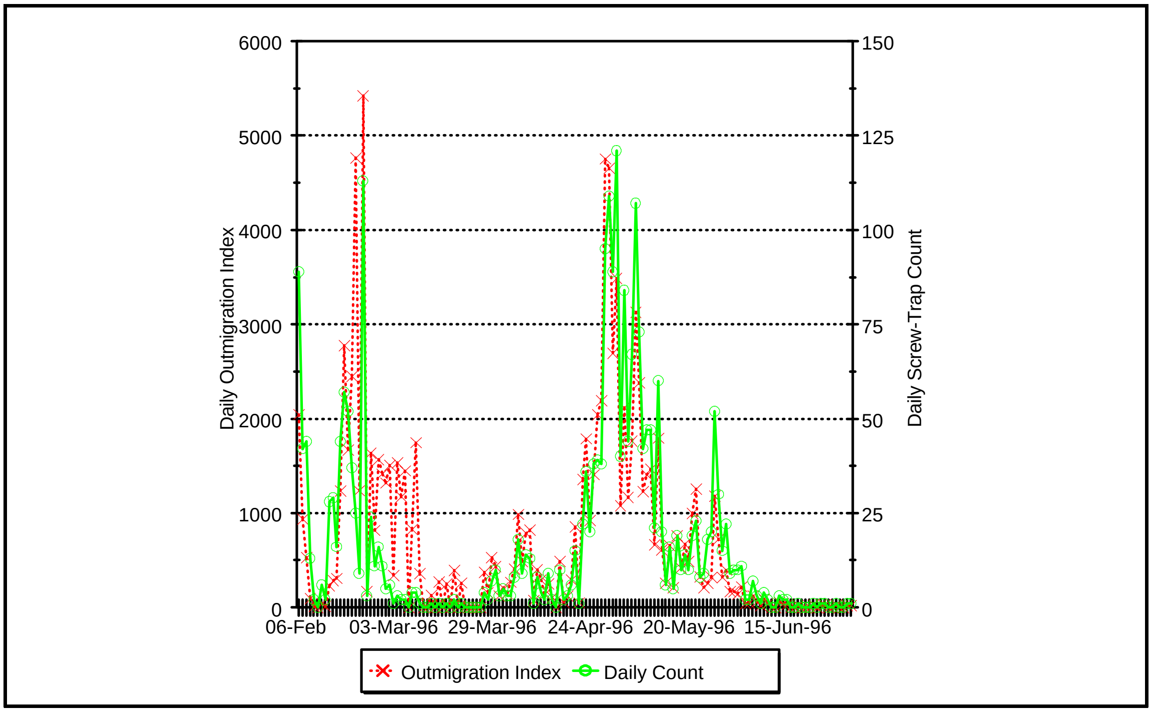


Figure A.2.a 1996 Caswell daily outmigration index (left vertical axis) and screw-trap count (right vertical axis).

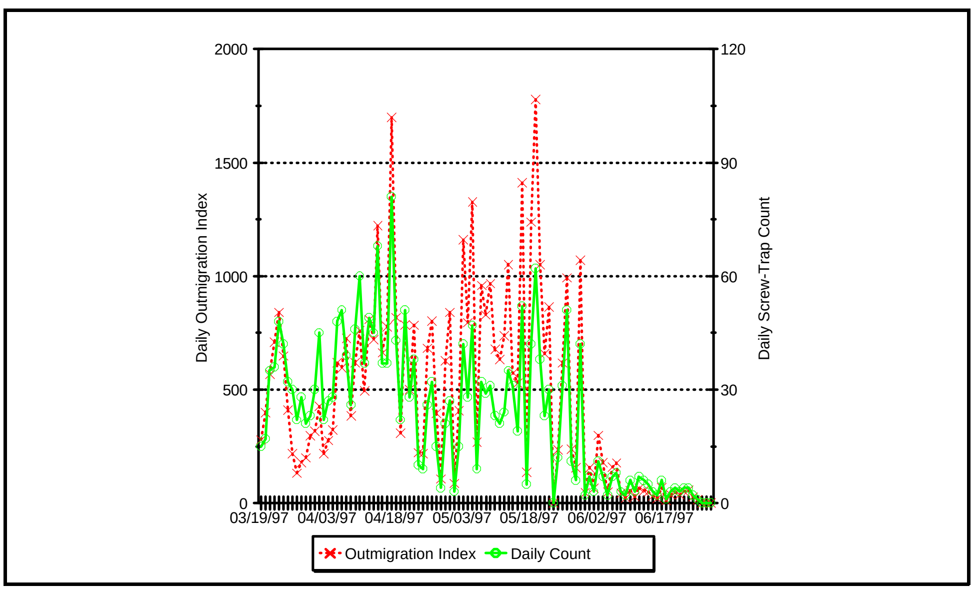


Figure A.2.b 1997 Caswell daily outmigration index (left vertical axis) and screw-trap count (right vertical axis).

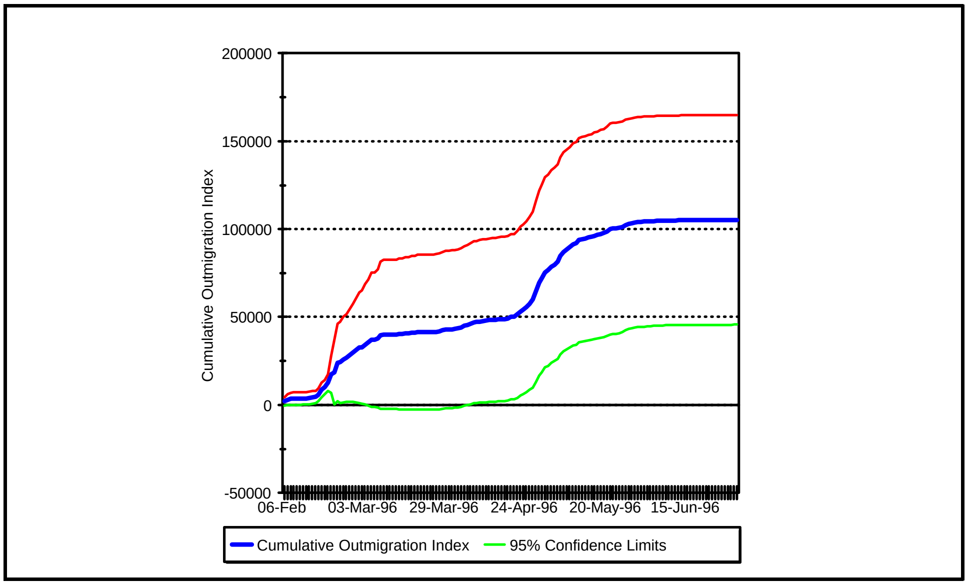


Figure A.3.a 1996 Caswell cumulative outmigration index from February 6 through July 1.

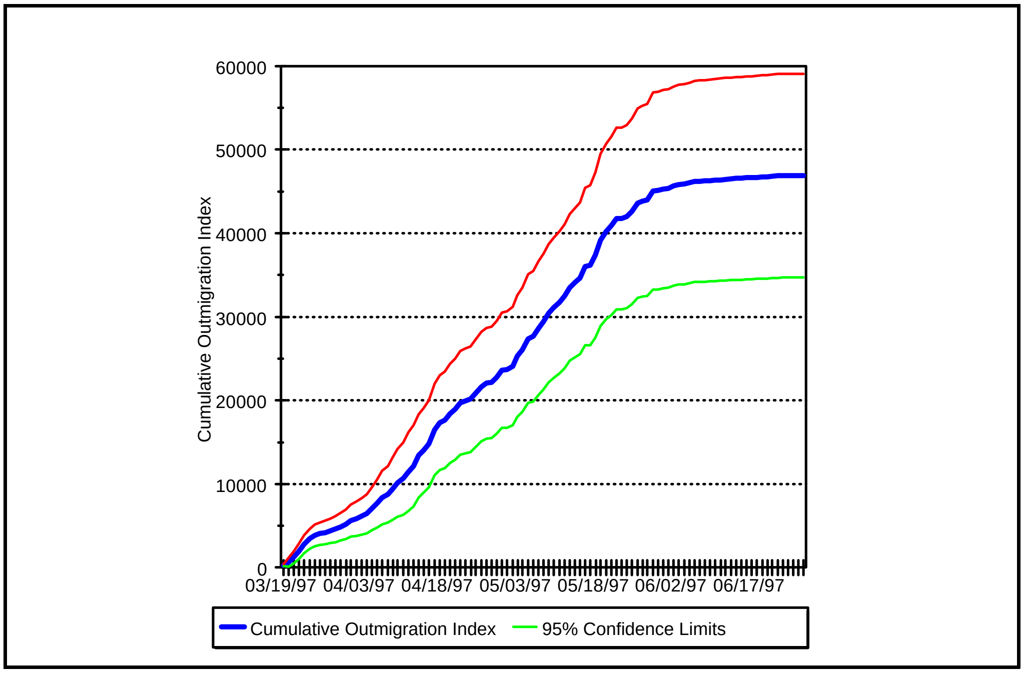


Figure A.3.b 1997 Caswell cumulative outmigration index from March 19 through June 27.

The approximate confidence intervals of the 1996 cumulative outmigration index were extremely large (Figure A.3.a), encompassing impossibly negative lower limits through much of the early passage period. This is reflected in the large coefficient of variation (CV) of the estimated February 6 through July 1 cumulative outmigration index

$$CV = 100\left[\frac{SE\ (\ Estimated\ Cumulative\ Outmigration\ Index\ )}{Estimated\ Cumulative\ Outmigration\ Index}\right] = 29\%$$

The approximate confidence intervals of the 1997 cumulative outmigration index were much smaller (Figure A.3.b), the associated coefficient of variation of the estimated February 6 through July 1 cumulative outmigration index being

$$CV = 100\left[\frac{SE\ (\ Estimated\ Cumulative\ Outmigration\ Index\ )}{Estimated\ Cumulative\ Outmigration\ Index}\right] = 13\%$$

The greater precision associated with the 1997 estimates relative to the 1996 estimates (narrower confidence intervals in 1997 Figure A.3.a compared to Figure A.3.b) was likely attributable to less variation in adjacent day capture counts in 1997 than in 1996. (Compare daily count fluctuations in 1997, Figure A.2.b, to those in 1996, Figure A.2.a.) Methods of approximating standard errors (SE) used in confidence intervals are discussed in Appendix A.2. The methods are somewhat different and more accurate than those used in 1996 report.

Appendix A.3 presents 1996 flows, turbidity, screw-trap counts, and efficiency-to-flow predictions, as well as associated daily and cumulative outmigration index estimates and their approximate standard errors. Appendix A.4 presents the 1997 values of the same variables.

Appendix A.1. Analysis of Variation Associated with Efficiency Predictor

Source	Deviance[1] (Dev)	Degrees of Freedom (D.F.)	Dev/D.F. Ratio[2]	F-Ratio
Flow, Turbidity	267.96	2	133.98	8.99[3]**
Flow (unadjusted)	110.42	1	110.42	7.41[3]**
Turbidity (unadjusted)	146.19	1	146.19	9.8[3]**
Flow (adjusted for Turbidity)	121.77	1	121.77	8.17[3]**
Turbidity (adjusted for Flow)	157.54	1	157.54	10.57[3]**
Residual	253.32	17	14.9	
Partitioning of Residual				
Variation among Days (Lack of Fit)	174.88	7	24.98	3.18[4]*
Variation within Days	78.44	10	7.84	

[1] Analogous to Sums of Squares

[2] Analogous Mean Square

[3] Source of denominator "Mean Square" is Residual

[4] Source of denominator "Mean Square" is Variation within Days

Appendix A.2. Standard Error for Cumulative Outmigration Index

In the following discussion, I use upper case letters to represent parameter values and corresponding lower case letters to represent their estimates.

The population daily outmigration index is

$$O_i = \frac{C_i}{E_i}$$

wherein O_i is the true daily outmigration index on day i, C_i is that day's expected count, and E_i is the true trap efficiency for that day. The true cumulative outmigration index is simply the daily index values added over days:

$$\Sigma_i O_i = \Sigma_i \frac{C_i}{E_i}$$

Substituting lower case letters for upper case letters gives the form of the estimated daily outmigration index

$$o_i = \frac{c_i}{e_i}$$

and the cumulative index

$$\Sigma_i o_i = \Sigma_i \frac{c_i}{e_i}$$

The variance of this cumulative passage is

$$S^2 [\Sigma_i o_i] = \Sigma_i Var[\frac{c_i}{e_i}] + \Sigma_i \Sigma_{i' \neq i} Cov [\frac{c_i}{e_i}, \frac{c_{i'}}{e_{i'}}]$$

Wherein Var is the variance of the daily outmigration index (day i) and Cov is the covariance between indices from different days (days i and i'). The standard error, SE, is the square root of the variance, S^2. In developing Var[$G_i o_i$], I first discuss Var[c_i/e_i] followed by Cov[$c_i/e_i, c_{i'}/e_{i'}$].

1. Var[c_i/e_i]

The variance of c_i/e_i can be approximated by variance of the ratio

$$Var[\frac{c_i}{e_i}] = \frac{C_i^2 Var[e_i]}{E_i^4} + \frac{Var[c_2]}{E_i^2} - 2 \times \frac{C_i Cov[c_i, e_i]}{E_i^3}$$

The methods used to estimate the components in the above equation are now discussed.

1.a. Estimates of C_i and E_i.

C_i and E_i, the actual parametric (population) values, are estimated by c_i and e_i, respectively. The substitution of c_i and e_i raised to powers 2, 3, and 4 for the corresponding powers of C_i and E_i lead to biases. No attempt was made to adjust for those biases or to assess the relative magnitude or direction of those biases.

1.b. Estimate of Var[e_i]

Recalling from the main appendix, the efficiency predictor is

$$e(_i) = \frac{1}{1 + \exp[a + b_f \times f(i) + b_t \times t(i)]}$$

The asymptotic form of the estimated variance of e_i can be developed by multiplying the variance-covariance matrix of a and b's by the vector of the first derivatives of e_i above with respect to the a and b's and post multiplying by the transpose of that vector (delta method), giving:

$$
\begin{gathered}
Var[e_i] = \\
E(\,)_i^4 \exp^2[a + b_f \cdot f(i) + b_t \cdot t(i)] \cdot \\
[Var(a) + f(i)^2 \cdot Var(b_t) + t(i)^2 \cdot Var(b_t) + \\
2 \cdot f(i) \cdot Cov(a,b_f) + 2 \cdot t(i) \cdot Cov(a,b_t) + 2 \cdot f(i) \cdot t(i) \cdot Cov(b_f,b_t)]
\end{gathered}
$$

1.c. Estimate of Var[c_i]

The variance in the count was approximated by taking the variance among the count of that day and the count(s) from immediately adjacent days.

$$
Var[c(i)] = \frac{[c(i-1)-\bar{c}(i)]^2 + [c(i)-\bar{c}(i)]^2 + [c(i+1)-\bar{c}(i)]^2}{n-1}
$$

wherein n = 3 if there are two adjacent days, n = 2 if there is only one adjacent day, and wherein

$$
\bar{c}(i) = \frac{c(i-1)+c(i)+c(i+1)}{n}
$$

This was different than the procedure used in the 1996 report.

1.d. Estimate of Cov[c_i, e_i]

The count and the predicted efficiency can be regarded as independent since they were based on different fish and since there is no reason to believe the fact that a given released fish used to estimate efficiency was captured affected the probability that a river-run fish used to estimate c_i was captured. Therefore

$$Cov[c_i, e_i] = 0$$

2. Cov[(c_i/e_i),($c_{i'}$/$e_{i'}$)]

There is a covariance between outmigration indices from different days. It is not equal to zero because the equations for predicting e_i and $e_{i'}$ used the same estimates of the intercept (a) and slope (b) parameters. The covariance was developed in a method analogous to that used for Var[e_i], the asymptotic covariance being

$$Cov[\frac{c_i}{e_i}, \frac{c_{i'}}{e_{i'}}] = (c_i c_j)(e_i e_j) \cdot [Var(a) + f_i \cdot f_{i'} \cdot Var(b_f) + t_i \cdot t_{i'} \cdot Var(b_t) + (f_i + f_{i'}) \cdot Cov(a,b_f) + (t_i + t_{i'}) \cdot Cov(a,b_t) \cdot Cov(a,b_f)]$$

3. Estimating Var(a), Var(b), and Cov(a,b)

Logistic regression was used to obtain the estimates of a and the b's and their variances and covariances. However, the variances and covariances so generated assumes that the distribution of the data points around the model (residuals) is binomially, meaning the expected ratio of the deviance to degrees of freedom (Dev/D.F.) is 1. When this is not the case, the variances and covariance estimates presented in logistic regression packages are underestimated and need to be expanded.

The residual deviance of 253 significantly (P < 0.0001) and substantially exceeded the residual degrees of freedom (Appendix A.1). Further, seventy-five percent of the absolute values of the twenty standardized residuals exceeded 1.96; only 5% would be expected to exceed 1.96 using normal approximation of the binomial. Either the distribution of efficiency is not binomial or the predictor variables do not adequately explain the variability. Therefore, the computer-output variances and covariances were expanded (multiplied) by Dev/D.F. to obtain estimates of the true variances and covariances.

There is evidence that the model is not sufficient in explaining as much of the day-to-day variation in trapping efficiency. The residual variation was partitioned into within-day and among-day sources. If the model explained all non-random variation, then the among-day variation would be expected to equal the within-day variation. The among-day source significantly exceeded the within-day source (Appendix A.1), suggesting the model was not sufficient.

4. Confidence Intervals

The 100*(1-á) confidence intervals of estimates were approximated using

$$\text{estimate} \pm z(\text{á})*SE(\text{estimate})$$

wherein z(á) is the two-sided standardized normal deviate associated with confidence probability 1-á and SE is the standard error or square root of the variance of the estimate.

Appendix A.3. **Flow, turbidity, screw-trap count, and predicted screw-trap efficiency and daily and cumulative outmigration index values based on trapping efficiency-to-flow relation, Caswell, 1996.**

							Daily Passage		Cumulative Passage	
Date	(OBB) Flow	Turbidity		Count		Efficiency	Estimate	SE	Passage	SE
06-Feb	355	3.7	*	89		0.01724	2048	1171.46	2048	1171.46
07-Feb	320	3.7		42		0.01724	938	723.46	2986	1621.56
08-Feb	306	7.6		44		0.03402	527	281.45	3513	1776.97
09-Feb	300	10.8		13		0.05873	96	164.26	3609	1804.1
10-Feb	516	14		2		0.09954	11	38.92	3620	1805.69
11-Feb	678	12		0		0.07177	0	25.44	3620	1805.87
12-Feb	681	13.5		6		0.09181	40	23.73	3660	1809.63
13-Feb	913	14.8		2		0.11311	13	93.29	3674	1812.38
14-Feb	1179	14.7		28		0.11133	232	141.15	3906	1812.99
15-Feb	1595	15.7		29		0.13028	289	112.23	4195	1784.11
16-Feb	1648	11.7		16		0.06828	310	276.03	4504	1789.48
17-Feb	1652	9.4		44		0.04633	1235	611.83	5739	1875.9
18-Feb	1650	6		57		0.02578	2777	684.78	8516	2126.54
19-Feb	2014	10.5		52		0.05584	1670	502.16	10186	2108.07
20-Feb	2841	10.5	*	37		0.05584	2450	1470.84	12635	2408.65
21-Feb	3223	6.1	*	24.7	*	0.02623	4766	4019.71	17401	5313.39
22-Feb	2797	6.1		9.4	*	0.02623	1239	7402.66	18640	9390.5
23-Feb	3093	13.8		113		0.09638	5426	4310.63	24067	11314.3
24-Feb	3245	13.6		3		0.09331	170	3313.08	24237	11848.7
25-Feb	3232	12.4		24		0.07668	1639	1229.47	25876	12481.6
26-Feb	3271	12.1		11		0.07297	817	700.85	26694	12821.2
27-Feb	3341	10.8		16		0.05873	1568	1034.63	28261	13520.2
28-Feb	3481	9.9		11		0.05045	1417	1197.45	29678	14249.5
29-Feb	3894	7.8		5		0.03522	1319	1381.78	30997	15106
01-Mar	3897	8.1		6		0.03708	1510	1413.18	32507	16108.6
02-Mar	3866	6.1	*	1		0.02623	342	903.51	32849	16359.6
03-Mar	3856	3.9	*	3.1	*	0.0177	1534	1433.32	34383	17426.4
04-Mar	3836	1.6	*	1.7	*	0.01191	1173	1209.49	35555	18278.3
05-Mar	3975	1.6		1.8	*	0.01191	1450	1595.69	37006	19423.2
06-Mar	3850	5.9		0		0.02533	0	697.52	37006	19435.7
07-Mar	3847	9		4		0.04327	829	820.01	37834	20020.9
08-Mar	3842	4.5		4		0.01984	1747	1669.88	39582	21332.5
09-Mar	3849	5.7		1		0.02447	360	807.02	39942	21612.7
10-Mar	3782	7		0		0.03067	0	157.52	39942	21613.3
11-Mar	3641	5.1		0		0.02203	0	190.71	39942	21614.1
12-Mar	3584	10.5		1		0.05584	128	117.27	40069	21694.4
13-Mar	3552	8		0		0.03645	0	108.64	40069	21694.6

					Daily Passage		Cumulative Passage	
Date	(OBB) Flow	Turbidity	Count	Efficiency	Estimate	SE	Passage	SE
14-Mar	3489	5.4	1	0.02322	274	254.55	40344	21872
15-Mar	3529	5.6	0	0.02404	0	158.78	40344	21872.6
16-Mar	3524	6	1	0.02578	256	237.97	40600	22039.8
17-Mar	3519	5.6	0	0.02404	0	272.57	40600	22041.5
18-Mar	3530	7.6	2	0.03402	394	361.16	40994	22295.2
19-Mar	3522	6.5	0	0.02812	0	235.22	40994	22296.4
20-Mar	3503	5.8	1	0.0249	260	240.73	41254	22465.6
21-Mar	3509	5.5	0	0.02363	0	158.59	41254	22466.2
22-Mar	3413	7.3	0	0.0323	0	0	41254	22466.2
23-Mar	3010	5.7	0	0.02447	0	0	41254	22466.2
24-Mar	2761	4.5	0	0.01984	0	0	41254	22466.2
25-Mar	2539	6	0	0.02578	0	246.4	41254	22467.5
26-Mar	2226	5.1	4	0.02203	375	232.25	41630	22576.8
27-Mar	2125	5.7	2	0.02447	155	201.91	41785	22617.3
28-Mar	2024	5.3	7	0.02282	532	348.53	42317	22741.8
29-Mar	1896	8	10	0.03645	435	177.46	42752	22816.4
30-Mar	1790	7.7	3	0.03461	125	152.15	42877	22834.7
31-Mar	1748	7.4	5	0.03287	211	62.81	43088	22863
01-Apr	1794	6.5	3	0.02812	153	67.97	43241	22886.8
02-Apr	1791	3	3	0.01524	271	278.69	43512	22938.9
03-Apr	1794	6.5	8	0.02812	407	399.39	43920	23005.7
04-Apr	1788	6	18	0.02578	990	384.31	44909	23165.8
05-Apr	1809	6.2	9	0.02669	488	270.14	45397	23247.5
06-Apr	1791	5.9	14	0.02533	785	241.6	46182	23376.3
07-Apr	1780	5.1	13	0.02203	823	509.48	47005	23520.3
08-Apr	1779	4.2	1	0.01882	73	442.89	47078	23537.7
09-Apr	1775	6.5	8	0.02812	401	196.67	47479	23600.4
10-Apr	1776	4.2	4	0.01882	293	240.93	47772	23654
11-Apr	1791	4.6	2	0.02019	139	253.58	47911	23680.4
12-Apr	1731	9.9	9	0.05045	249	118.27	48160	23707.4
13-Apr	1598	5.2	2	0.02242	106	252.14	48266	23721.4
14-Apr	1595	9.7	0	0.04876	0	134.68	48266	23721.8
15-Apr	1599	5.7	10	0.02447	489	281.18	48755	23779.5
16-Apr	1656	9.3	2	0.04555	57	124.97	48813	23785.2
17-Apr	1706	7.2	3	0.03175	126	90.59	48939	23801.7
18-Apr	1711	6.3	6	0.02716	294	312.02	49232	23845
19-Apr	1679	5.2	15	0.02242	855	458.46	50087	23972
20-Apr	1670	5.6	1	0.02404	53	566.21	50140	23986
21-Apr	1675	4.7	22	0.02054	1356	1147.46	51496	24215.7
22-Apr	1673	6	36	0.02578	1789	586.82	53286	24466.6
23-Apr	1668	6.4	20	0.02764	927	495.52	54213	24594.4
24-Apr	1673	7.8	38	0.03522	1407	458.37	55620	24764
25-Apr	1676	5.7	39	0.02447	2042	476.44	57662	25064.2

					Daily Passage		Cumulative Passage	
Date	(OBB) Flow	Turbidity	Count	Efficiency	Estimate	SE	Passage	SE
26-Apr	1676	5.1	38	0.02203	2196	1967.33	59858	25480.8
27-Apr	1662	5.9	95	0.02533	4754	2161.12	64612	26247.5
28-Apr	1668	6.9	109	0.03014	4655	982.89	69267	26891.3
29-Apr	1684	9.1	89	0.04402	2695	625.59	71962	27191
30-Apr	1683	9.4	121	0.04633	3487	1276.86	75449	27584.7
01-May	1684	9.8 *	40	0.0496	1082	1107.35	76530	27715.3
02-May	1680	10.2	84	0.05308	2122	687.45	78653	27921.8
03-May	1659	9.8	44	0.0496	1164	555.28	79817	28037.5
04-May	1674	9.9	67	0.05045	1767	877.51	81584	28223.5
05-May	1662	9.2	107	0.04478	3128	767.55	84712	28561.8
06-May	1640	8.4	73	0.03905	2383	1116.78	87095	28849.5
07-May	1664	9.2	42	0.04478	1230	516.96	88325	28985.9
08-May	1650	9	47	0.04327	1404	213.87	89729	29136.6
09-May	1663	8.8	47	0.04182	1467	513.75	91196	29307.5
10-May	1667	8.7	21	0.04111	668	639.56	91865	29392.3
11-May	1653	9	60	0.04327	1797	728.11	93662	29596
12-May	1644	8.8	20	0.04182	614	864.7	94276	29675.8
13-May	1662 *	6.8	6	0.02962	259	315.3	94535	29714.8
14-May	1668 *	7.1	16	0.0312	661	278.95	95196	29809.3
15-May	1673 *	6.9	5	0.03014	214	318.76	95411	29842.2
16-May	1673 *	7.3	19	0.0323	764	315.72	96175	29950.5
17-May	1698	7.1	10	0.0312	424	207.21	96599	30014.8
18-May	1658	6.1	14	0.02623	676	183.32	97275	30119.4
19-May	1693	6.2	10	0.02669	490	244.9	97764	30199.9
20-May	1697	5.8	19	0.0249	997	418.85	98761	30371.8
21-May	1670	5.4	23	0.02322	1258	524.12	100019	30589.3
22-May	1525	6.4	8	0.02764	327	348.66	100346	30629.5
23-May	1151	7.9	9	0.03583	209	132.13	100555	30629.2
24-May	936	9.8	18	0.0496	258	97.26	100813	30607.8
25-May	901	8.9	20	0.04254	321	312.33	101134	30583.9
26-May	921	6.8	52	0.02962	1183	458.82	102316	30534.6
27-May	955	6.6	30	0.02861	725	478.66	103042	30515.8
28-May	958	7.4	15	0.03287	320	173.03	103361	30503.1
29-May	935	8.3	22	0.03838	399	141.45	103760	30479.6
30-May	935	7.9	9	0.03583	174	144.03	103934	30470.7
31-May	939	8.6	10	0.04041	173	34.75	104108	30459.9
01-Jun	945	9.8	10	0.0496	144	28.39	104252	30448.7
02-Jun	939	7.7	11	0.03461	220	108.39	104472	30438.1
03-Jun	933	6.8	2	0.02962	46	119.83	104518	30436.7
04-Jun	936	6.6	2	0.02861	48	69.52	104566	30435.2
05-Jun	933	8.3	7	0.03838	127	53.95	104692	30427.8
06-Jun	929	7.4	3	0.03287	62	64.92	104755	30425
07-Jun	976	7.9	1	0.03583	20	30.79	104775	30424.2

						Daily Passage		Cumulative Passage	
Date	(OBB) Flow	Turbidity		Count	Efficiency	Estimate	SE	Passage	SE
08-Jun	1281	8.6		4	0.04041	93	37.43	104867	30426.4
09-Jun	1275	8.6	*	2	0.04041	46	46.55	104914	30427.5
10-Jun	1279	8.6	*	0	0.04041	0	26.74	104914	30427.5
11-Jun	1300	9.2	*	0	0.0444	0	37.1	104914	30427.5
12-Jun	1308	9.7	*	3	0.04876	60	31.29	104973	30428.3
13-Jun	1292	9.7	*	2	0.04876	39	12.34	105013	30428.7
14-Jun	1200	9.7		2	0.04876	36	21.56	105049	30428.2
15-Jun	1077	8.8		0	0.04182	0	21.81	105049	30428.2
16-Jun	928	8.3		0	0.03838	0	10.4	105049	30428.2
17-Jun	848	7.5		1	0.03344	19	11.86	105068	30426.9
18-Jun	850	4.9		0	0.02128	0	16.77	105068	30426.9
19-Jun	844	5.3		0	0.02282	0	0	105068	30426.9
20-Jun	829	6.7		0	0.02911	0	12.33	105068	30426.9
21-Jun	821	6		1	0.02578	24	15.1	105092	30425.7
22-Jun	833	5.6		0	0.02404	0	14.76	105092	30425.7
23-Jun	811	5.7		1	0.02447	25	15.83	105116	30424.5
24-Jun	825	5.3		1	0.02282	27	17.19	105143	30423.4
25-Jun	842	5		0	0.02165	0	16.38	105143	30423.4
26-Jun	852	4.8		0	0.02091	0	17.07	105143	30423.4
27-Jun	831	5.4		1	0.02322	26	16.96	105169	30422.4
28-Jun	815	5.6		0	0.02404	0	14.53	105169	30422.4
29-Jun	776	6.4		0	0.02764	0	12.37	105169	30422.4
30-Jun	757	6.7		1	0.02911	20	12.76	105190	30420.8
01-Jul	752	6.7	*	1	0.02911	20	5.31	105210	30419.3

* Missing value substitutions

Appendix A.4. **Flow, turbidity, screw-trap count, and predicted screw-trap efficiency and daily and cumulative outmigration index values based on trapping efficiency to turbidity relation, Caswell, 1997.**

					Daily Passage		Cumulative Passage	
Date	(OBB) Flow	Turbidity	Count	Efficiency	Estimate	SE	Estimate	SE
03/19/97	1618	11.8	15	0.05387	278	53.52	278	53.52
03/20/97	1631	10.4	17	0.04262	399	264.34	677	278.47
03/21/97	1645	12.8	35	0.06165	568	207.48	1245	376.69
03/22/97	1558	11.1	36	0.05072	710	175.37	1955	463.55
03/23/97	1362	10.8	48	0.0571	841	153.63	2795	546.27
03/24/97	1175	10.6	42	0.06474	649	158.18	3444	616.4
03/25/97	876	10.2	32	0.078	410	118.16	3854	659.55
03/26/97	524	12.1	30	0.13742	218	76.99	4073	693.45
03/27/97	621	14	22	0.16719	132	48.33	4204	719.38
03/28/97	595	13.4	28	0.15672	179	60.29	4383	755.15
03/29/97	601	10.7	21	0.10526	200	64.79	4582	788.49
03/30/97	605	8.7	23	0.07738	297	101.79	4880	832.19
03/31/97	616	10.1	30	0.09501	316	145.66	5195	897.39
04/01/97	618	10.8	45	0.1054	427	160.59	5622	991.55
04/02/97	614	10.5	* 22	0.10108	218	133.45	5840	1044.25
04/03/97	597	10.2	27	0.09795	276	82.38	6116	1103.64
04/04/97	599	9.4	28	0.0866	323	162.77	6439	1179.21
04/05/97	602	8.7	48	0.07757	619	234.26	7058	1318.54
04/06/97	597	9.3	51	0.08542	597	178.9	7655	1456.89
04/07/97	590	6.3	39	0.05382	725	324.17	8379	1626.6
04/08/97	602	7.8	26	0.06746	385	185.88	8765	1723.25
04/09/97	599	8.4	46	0.07424	620	287.38	9384	1888.14
04/10/97	598	8.8	60	0.07904	759	255.22	10144	2082.61
04/11/97	589	8.4	37	0.07486	494	206.9	10638	2213.18
04/12/97	730	7.8	49	0.0606	809	226.76	11446	2395.4
04/13/97	1164	10.3	45	0.06234	722	223.92	12168	2497.76
04/14/97	1711	12.5	68	0.05563	1222	377.97	13391	2538.67
04/15/97	1707	12.5	37	0.05582	663	346.6	14054	2581.94
04/16/97	1651	11.2	37	0.04762	777	547.17	14831	2669.18
04/17/97	1668	11.3	81	0.04769	1699	570.27	16529	2799.81
04/18/97	1684	12	43	0.05258	818	587.69	17347	2910.12
04/19/97	1680	13.9	22	0.07111	309	223.44	17656	2947.34
04/20/97	1695	13.4	51	0.06496	785	294.8	18441	3031.11
04/21/97	1685	12.4	28	0.05597	500	227.47	18942	3082.61

					Daily Passage		Cumulative Passage	
Date	(OBB) Flow	Turbidity	Count	Efficiency	Estimate	SE	Estimate	SE
04/22/97	1668	11.4	38	0.04845	784	319.65	19726	3159.27
04/23/97	1679	11	10	0.04503	222	367.21	19948	3196.9
04/24/97	1687 *	10.5	9	0.04128	218	233.36	20166	3219.63
04/25/97	1686	10	26	0.03813	682	328.05	20848	3275.56
04/26/97	1691	10.3	32	0.03984	803	246.86	21651	3337.34
04/27/97	1716	10.1	15	0.03776	397	378.37	22048	3383.78
04/28/97	1685	9.9	4	0.03755	107	230.11	22155	3398.56
04/29/97	1686	9.2	21	0.03351	627	367.33	22782	3451.75
04/30/97	1680	8.9	27	0.03209	841	408.09	23623	3519.31
05/01/97	1682	9.4	3	0.03473	86	345.74	23709	3541.78
05/02/97	1672	9.7	15	0.03677	408	546.27	24117	3611.83
05/03/97	1653	9.5	42	0.03619	1161	405.73	25278	3714
05/04/97	1648	9.3	28	0.03519	796	300.35	26074	3782.02
05/05/97	1659	9.4	47	0.03543	1327	566.94	27400	3920.58
05/06/97	1633	8.9	9	0.03342	269	573.92	27670	3981.71
05/07/97	1653	9	32	0.03338	959	397.83	28628	4070.66
05/08/97	1636	9.2	29	0.03499	829	120.54	29457	4137.95
05/09/97	1662	8.8	31	0.03207	967	190.02	30424	4214.7
05/10/97	1652	9.1	23	0.03396	677	182.03	31101	4274.49
05/11/97	1639	8.9	21	0.03325	632	98.82	31733	4327.79
05/12/97	1642	8.8	24	0.03263	736	248.32	32468	4395.88
05/13/97	1581	8.6	35	0.0333	1051	218.63	33519	4489.94
05/14/97	1038	8.7	31	0.05387	575	182.62	34095	4552.14
05/15/97	1571	9	19	0.03583	530	471.06	34625	4624.68
05/16/97	1613	9.4	52	0.03686	1411	680.33	36036	4805.31
05/17/97	1602	9.3	5	0.03662	137	676.4	36172	4865.63
05/18/97	1616	8.9	42	0.03391	1238	868.95	37411	5052.56
05/19/97	1621	9.1	62	0.03488	1778	438.81	39188	5235.23
05/20/97	1598	9.2	38	0.03616	1051	560.97	40240	5366.29
05/21/97	1600	9	23	0.03495	658	231.59	40898	5434.75
05/22/97	1607	9 *	30	0.03474	864	466.14	41761	5538.34
05/23/97	1506	9.2 *	0	0.03914	0	385.83	41761	5551.76
05/24/97	1218	9.3 *	12	0.05086	236	308.91	41997	5583.82
05/25/97	1233	9.3	31	0.05022	617	396.61	42615	5659.17
05/26/97	1224	9.4	51	0.05141	992	410.35	43607	5773.3
05/27/97	1398	9.7	11	0.04651	237	531.05	43843	5822
05/28/97	1608	9.6	6	0.03823	157	510.51	44000	5860.21
05/29/97	1615	9.8	42	0.03925	1070	578.81	45070	5997.12
05/30/97	1468	9.5	2	0.04243	47	513.72	45117	6023.85
05/31/97	1395	9.4	7	0.04445	157	62.3	45275	6040.01

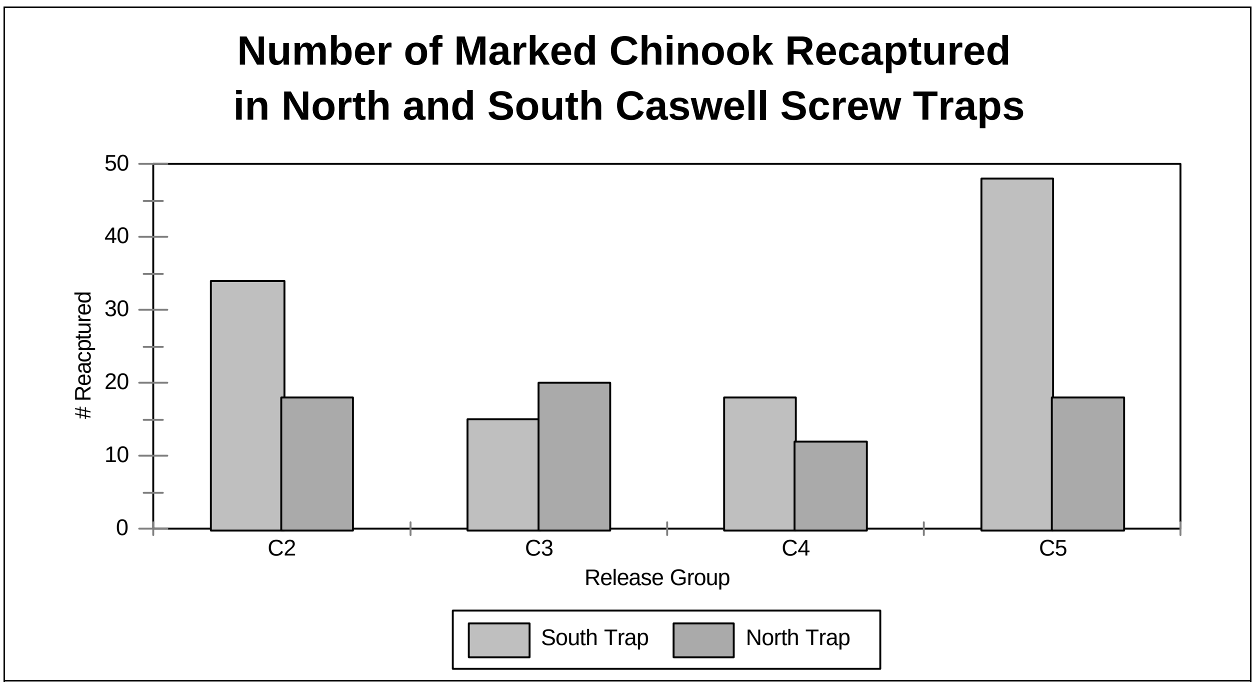
Date	(OBB) Flow	Turbidity		Count	Efficiency	Daily Passage Estimate	Daily Passage SE	Cumulative Passage Estimate	Cumulative Passage SE
06/01/97	1386	9.5		3	0.04551	66	88.23	45341	6047.33
06/02/97	1594	9.3		11	0.03687	298	115.1	45639	6078.19
06/03/97	1603	9.7		7	0.03902	179	117.89	45818	6097.75
06/04/97	1611	10.2		2	0.04199	48	69.04	45866	6103.2
06/05/97	1609	10.5		7	0.04414	159	76.04	46025	6120.79
06/06/97	1547	10.3		8	0.04507	177	62.95	46202	6140.05
06/07/97	1194	11.1		3	0.0689	44	47.15	46246	6145.04
06/08/97	949	11.5		2	0.08968	22	23.67	46268	6147.56
06/09/97	907	12.6		6	0.1095	55	23.06	46323	6153.97
06/10/97	924	12.9		3	0.11296	27	19.52	46349	6157.14
06/11/97	917	12.5		7	0.10702	65	24.76	46415	6164.79
06/12/97	913	12.6		6	0.10898	55	15.97	46470	6171.27
06/13/97	915	12.3		5	0.10403	48	18.39	46518	6176.88
06/14/97	908	11.9		3	0.09851	30	16.93	46548	6180.39
06/15/97	905	12.1		2	0.10177	20	20.94	46568	6182.7
06/16/97	908	11.2	*	6	0.08858	68	33.11	46636	6190.32
06/17/97	903	10.2		1	0.07628	13	33.1	46649	6191.8
06/18/97	896	10.7		3	0.08287	36	19.89	46685	6195.77
06/19/97	898	11		4	0.08662	46	11.77	46731	6200.89
06/20/97	912	10.6		3	0.08054	37	10.39	46769	6204.95
06/21/97	921	10.5		4	0.07872	51	12.48	46819	6210.47
06/22/97	916	9.8		4	0.07092	56	19.64	46876	6216.39
06/23/97	918	10.1		2	0.07418	27	21.26	46903	6219.3
06/24/97	925	9.6		1	0.06824	15	14.92	46917	6220.84
06/25/97	917	10.3		0	0.07658	0	7.54	46917	6220.84
06/26/97	882	10.7		0	0.08382	0	0	46917	6220.84
06/27/97	792	11.4		0	0.10031	0	0	46917	6220.84

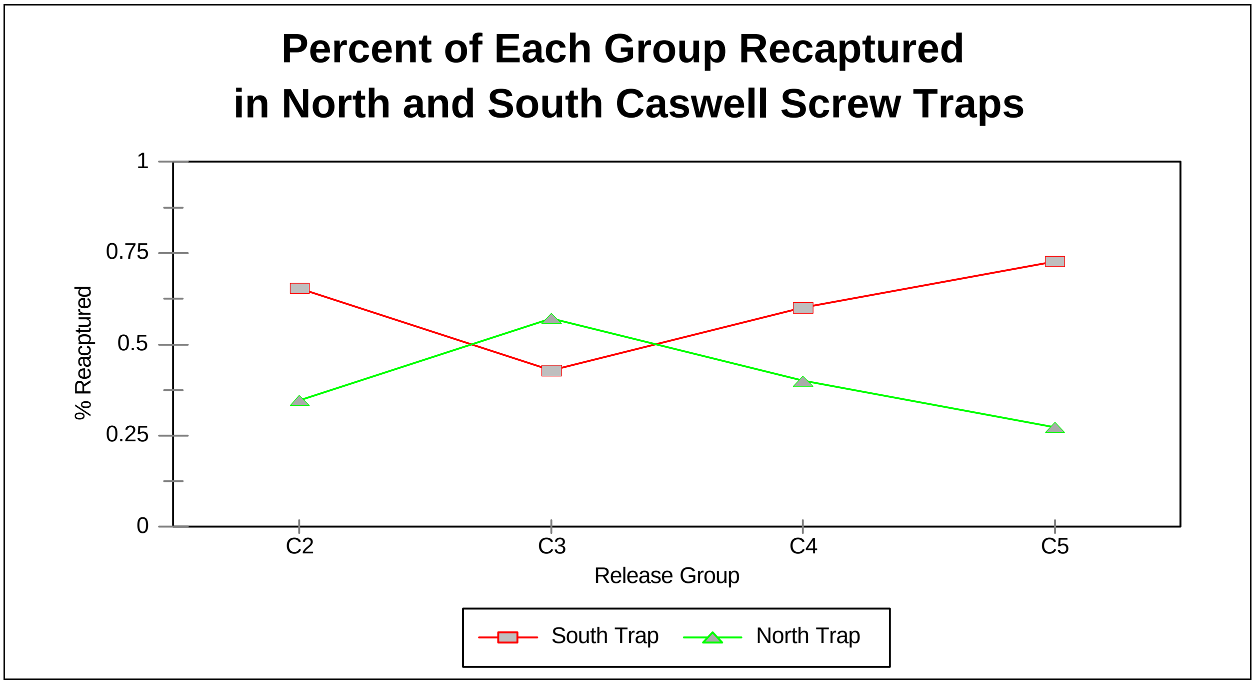
* Missing value substitution

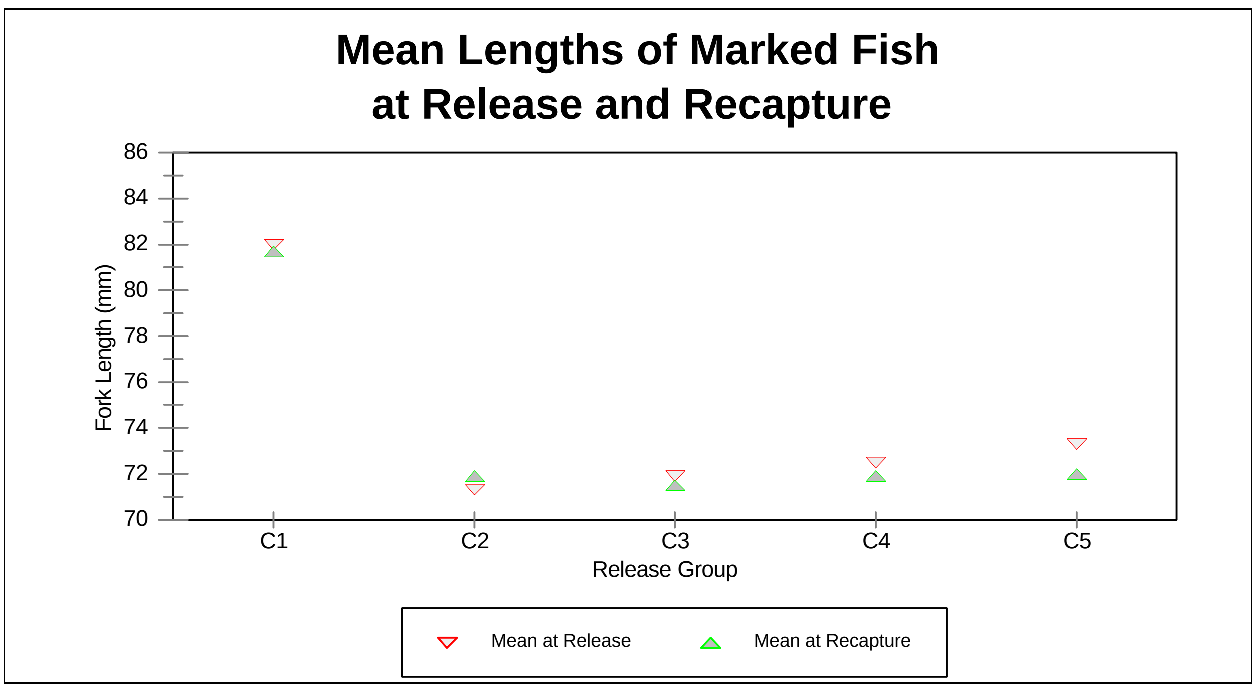
Appendix 2. Recapture data for individual marked chinook captured at Caswell, 1997.

	C2 **# Recap**	C3 **# Recap**	C4 **# Recap**	C5 **# Recap**
South	34	15	18	48
North	18	20	12	18
Total	52	35	30	66

	C2 **% Recap**	C3 **% Recap**	C4 **% Recap**	C5 **% Recap**
% South	65.4%	42.9%	60.0%	72.7%
% North	34.6%	57.1%	40.0%	27.3%
Total	100%	100%	100%	100%




Percent of Each Group Recaptured
in North and South Caswell Screw Traps
% Reacptured
1
0.75
0.5
0.25
0
C2
C3
C4
C5
Release Group
South Trap
North Trap


Mean Lengths of Marked Fish
at Release and Recapture
Fork Length (mm)
86
84
82
80
78
76
74
72
70
C1
C2
C3
C4
C5
Release Group
Mean at Release
Mean at Recapture

Appendix 3. Depth-velocity profiles made in front of Caswell screw traps in 1997.

03/21/97	Front of Trap			Rear of Trap		
Distance From North Bank (ft)	Max Depth (ft)	Vel. at 20% of Depth (ft/sec)	Vel. at 80% of Depth (ft/sec)	Max Depth (ft)	Vel. at 20% of Depth (ft/sec)	Vel. at 80% of Depth (ft/sec)
4	8.5	0	0	8.75	0.6	0.6
8	10.75	2.5	2.6	12.25	1.7	2.5
12	11	2.6	2.7	12	2	2.4
16	10.75	3.1	3	12.75	nd	nd
20	11.5	2.9	2.9	11.25	nd	nd
24	11.75	3.2	3.2	10.75	nd	nd
28	11.5	2.8	2.8	11	nd	nd
32	11	2.7	3	11.5	nd	nd
36	11.25	2.4	2.3	11	3.1	3
40	10.75	2.4	2.3	11.25	2.7	2.6
44	10.5	2.2	2	11.75	3	3
48	10.25	2.3	2.5	10.5	2.9	2.5
52	10	2.4	2.4	10.25	2.8	2.7
56	9	2.3	2.6	10.25	2.6	2.5
60	9.75	2.3	2.3	10	2.4	2.1
64	8.25	0.8	nd	9.5	1.7	nd
68	nd	nd	nd	nd	nd	nd
72	0	-	-	0	-	-

nd = Measurement not taken due to obstruction.

	Front of Trap			Front of Trap		
	03/27/97	03/27/97	03/27/97	04/06/97	04/06/97	04/06/97
Distance From North Bank (ft)	Max Depth (ft)	Vel. at 1 ft Depth (ft/sec)	Vel. at 4 ft Depth (ft/sec)	Max Depth (ft)	Vel. at 1 ft Depth (ft/sec)	Vel. at 4 ft Depth (ft/sec)
3	4.75	0	0	5	nd	nd
6	6.5	0.2	0.3	6.75	nd	nd
9	7.25	1.1	1.9	7.25	2.1	1.9
12	7.75	1.6	1.5	7	2.3	2.6
15	7.5	2.2	2.1	7.25	nd	nd
18	7.75	2.2	1.9	7.5	nd	nd
21	8	2.1	2.1	7.5	nd	nd
24	8.25	2.4	2.5	7.5	nd	nd
27	8	2.3	2.1	7.5	nd	nd
30	8	2.2	1.6	7.25	nd	nd
33	8.25	1.4	1.7	7.25	nd	nd
36	7.25	1.2	1.2	6.75	nd	nd
39	7	1.3	1.3	6.5	nd	nd
42	7	1.5	1.3	5.5	nd	nd
45	6.75	1.7	1.7	5.25	nd	nd
48	6.5	1.6	1.5	6	nd	nd
51	6.75	1.9	1.7	5.5	nd	nd
54	6.5	1.7	1.5	3	nd	nd
57	4.25	0.4	0.5	0	-	-
60	nd	nd	nd	-	-	-
63	0	-	-	-	-	-
66	-	-	-	-	-	-

nd = Measurement not taken due to obstruction.

	Front of Trap			Front of Trap		

Distance From North Bank (ft)	04/12/97 Max Depth (ft)	04/12/97 Vel. at 1 ft Depth (ft/sec)	04/12/97 Vel. at 4 ft Depth (ft/sec)	04/14/97 Max Depth (ft)	04/14/97 Vel. at 1 ft Depth (ft/sec)	04/14/97 Vel. at 4 ft Depth (ft/sec)
3	4	1.4	1.4	2.25	0	0
6	6	2.2	2.1	4.75	0.2	0
9	7	2.4	2.4	6.75	0.8	1.3
12	6.5	2.3	2.3	8.25	1.6	1.8
15	6.75	2.3	2.2	8	2.7	2.6
18	7.25	2.2	2.2	8	2.7	2.8
21	7	2.3	2.3	8.25	2.8	3.1
24	7.25	2.2	2.2	8.75	2.9	2.9
27	6.75	2	2	8.75	2.7	2.9
30	7	1.9	1.9	9	2.4	2.3
33	6.75	1.5	1.4	9.25	1.9	1.8
36	6.5	1.2	1.1	8.25	1.9	1.9
39	5.75	1.4	1.1	7.5	2	1.6
42	5.5	1.7	1.3	7.5	2.1	1.7
45	5.5	1.7	1.7	7	1.8	2.1
48	6	1.7	1.7	7	2	2
51	3	0.5	0.6	7.25	2.4	2
54	nd	nd	nd	7	1.2	2.1
57	0	-	-	nd	nd	nd
60	-	-	-	0	-	-
63	-	-	-	-	-	-
66	-	-	-	-	-	-

nd = Measurement not taken due to obstruction.

Distance From North Bank (ft)	04/15/97 Max Depth (ft)	Front of Trap 04/15/97 Vel. at 1 ft Depth (ft/sec)	04/15/97 Vel. at 4 ft Depth (ft/sec)	04/19/97 Max Depth (ft)	Front of Trap 04/19/97 Vel. at 1 ft Depth (ft/sec)	04/19/97 Vel. at 4 ft Depth (ft/sec)
3	2.75	0	0	2.75	0	0
6	6	0	0	7.5	0	0
9	7.5	0	0	8.5	0.5	0
12	8	0.4	0	10.5	2.6	2.8
15	9.75	3.1	2.8	11	2.8	2.8
18	9.5	2.9	2.8	10	2.8	2.7
21	9.5	2.8	2.9	10	2.7	2.8
24	9.75	2.8	2.9	10.25	3	2.9
27	10	3.1	3.1	10.5	3.1	3
30	10.25	3.1	3.1	10	2.8	2.9
33	10	2.9	3.1	11	2	2.1
36	10.25	2.5	2.7	10	2.1	2.3
39	9.5	2.1	2.4	10	2.1	2.1
42	9	1.8	1.9	9.75	2.5	2.4
45	9	2.1	2.3	9.5	2.6	2.6
48	8.5	2.3	2.4	9.5	2.6	2.6
51	8.5	2.5	2.3	9	2.8	2.8
54	8.75	2.4	2.5	8.5	2.7	2.8
57	7.75	2.3	2.3	8.75	1.9	2.2
60	5	nd	nd	8	0.7	nd
63	0	-	-	4	nd	nd
66	-	-	-	0	-	-

nd = Measurement not taken due to obstruction.

Distance From North Bank (ft)	05/06/97 Max Depth (ft)	Front of Trap 05/06/97 Vel. at 1 ft Depth (ft/sec)	05/06/97 Vel. at 4 ft Depth (ft/sec)	05/20/97 Max Depth (ft)	Front of Trap 05/20/97 Vel. at 1 ft Depth (ft/sec)	05/20/97 Vel. at 4 ft Depth (ft/sec)
3	2.5	0	0	3	0	0
6	5	0	0	5	0	0
9	6.75	0	0	7	1	0.7
12	9.5	0	0	9.25	1.7	2.7
15	9.5	2.6	2.7	9.5	2.8	2.9

18	9.25	2.7	2.6	9.25	2.8	3
21	9.5	2.9	3	9.5	3.1	3.3
24	9.5	2.9	2.9	10	3	3
27	10.25	2.9	2.9	11	2.8	2.8
30	10	3.2	3	10	2.8	2.8
33	11	2.2	2.1	11	2.7	2.6
36	10.75	2.3	2.3	10.25	2.5	2.5
39	10	2.1	2.2	9.75	2.5	2.5
42	10	2.1	2.1	9.5	2.4	2.4
45	9.5	2.4	2.4	9.25	2.4	2.4
48	9.25	2.5	2.6	9	2.3	2.3
51	9.25	2.8	2.7	9	2.3	2.3
54	9.25	2.8	2.7	8.5	2.2	2.2
57	9	2	2.1	9.5	3	3
60	7.5	0.3	0.3	7.5	1	0.7
63	nd	nd	nd	4	nd	nd
66	0	-	-	0	-	-

nd = Measurement not taken due to obstruction.

Distance From North Bank (ft)	05/28/97 Max Depth (ft)	Front of Trap 05/28/97 Vel. at 1 ft Depth (ft/sec)	05/28/97 Vel. at 4 ft Depth (ft/sec)	06/12/97 Max Depth (ft)	Front of Trap 06/12/97 Vel. at 1 ft Depth (ft/sec)	06/12/97 Vel. at 4 ft Depth (ft/sec)
3	2.75	0	0	4	0	0
6	7.75	0	0	6.5	0	0.4
9	9.25	2.4	1.5	7.25	0.9	1
12	9.25	2.9	3.1	7.5	2.4	2.3
15	9	3.1	2.7	7.5	2.4	2.4
18	9.5	2.4	3.1	7.5	2.5	2.3
21	9.75	2.5	3.4	7.75	2.6	2.7
24	9.75	3.3	3.1	7.75	2.7	2.7
27	9.5	3.2	3.2	7.5	2.8	2.7
30	9.5	2.8	3	7.75	2.7	2.6
33	9.5	2.2	2.6	8	2.4	2.3
36	9.5	2.2	2	7.5	1.9	1.7
39	9.25	2.3	2	7.25	1.7	1.5
42	9	2	2.3	7.25	1.6	1.5
45	9	2.5	2.7	6.75	1.5	1.7
48	8.5	3	2.7	6.5	1.8	1.7
51	9	2.7	2.6	7	1.8	1.9
54	9	2.8	2.8	7	1.1	1
57	8.75	2	2.3	6.5	0.7	0.6
60	6.75	0.7	nd	4	nd	nd
63	nd	nd	nd	0	-	-
66	0	-	-	-	-	-

nd = Measurement not taken due to obstruction.

Distance From North Bank (ft)	06/23/97 Max Depth (ft)	Front of Trap 06/23/97 Vel. at 1 ft Depth (ft/sec)	06/23/97 Vel. at 4 ft Depth (ft/sec)	06/25/97 Max Depth (ft)	Front of Trap 06/25/97 Vel. at 1 ft Depth (ft/sec)	06/25/97 Vel. at 4 ft Depth (ft/sec)
3	3	0	0	2	0	0
6	6	0	0.7	4	0	0
9	7.25	0.2	0.5	6	0	0
12	7.25	2.6	2.3	7.25	2.6	2.3
15	7.25	2.3	2.5	7	2.7	2.7
18	7.5	2.5	2.5	7.25	2.7	2.5
21	7.25	2.9	2.8	7.25	2.7	2.7
24	7.25	2.6	2.6	7.5	2.6	2.7
27	7.25	2.6	2.6	7.5	3.1	2.9
30	7.75	2.5	2.4	8	2.5	2.4
33	7.75	2.3	2.1	8	2	1.7
36	7.5	1.8	1.7	7.25	1.7	1.6
39	7.5	1.6	1.6	7	1.4	1.2

42	7	1.4	1.4	6.75	1.7	1.5
45	6.75	1.5	1.8	6.5	1.2	1.2
48	6.5	2	1.7	6.75	1.5	1.6
51	7	1.9	1.9	7	1.6	1.6
54	7.25	0.7	0.7	7.25	1.6	1.6
57	7.25	0	0	4	0.5	0
60	5	nd	nd	0	-	-
63	0	-	-	-	-	-
66	-	-	-	-	-	-

nd = Measurement not taken due to obstruction.

		Front of Trap	
Distance From North Bank (ft)	06/27/97 Max Depth (ft)	06/27/97 Vel. at 1 ft Depth (ft/sec)	06/27/97 Vel. at 4 ft Depth (ft/sec)
3	2	0	0
6	4	0	0
9	6	0.4	0.4
12	7.25	0.8	0.7
15	7.5	2.4	2.2
18	7.25	2.5	2.7
21	7.5	2.7	2.7
24	7.5	2.6	2.6
27	7.25	2.6	2.5
30	7.5	2.7	2.7
33	8.25	2.7	2.7
36	8	2.6	2.4
39	7.25	2	1.9
42	7	1.3	1.4
45	6.75	1	1.1
48	6.5	1.2	1.2
51	7.25	2.3	1.8
54	5	0.5	1.3
57	3	0	0
60	0	-	-
63	-	-	-
66	-	-	-

nd = Measurement not taken due to obstruction.

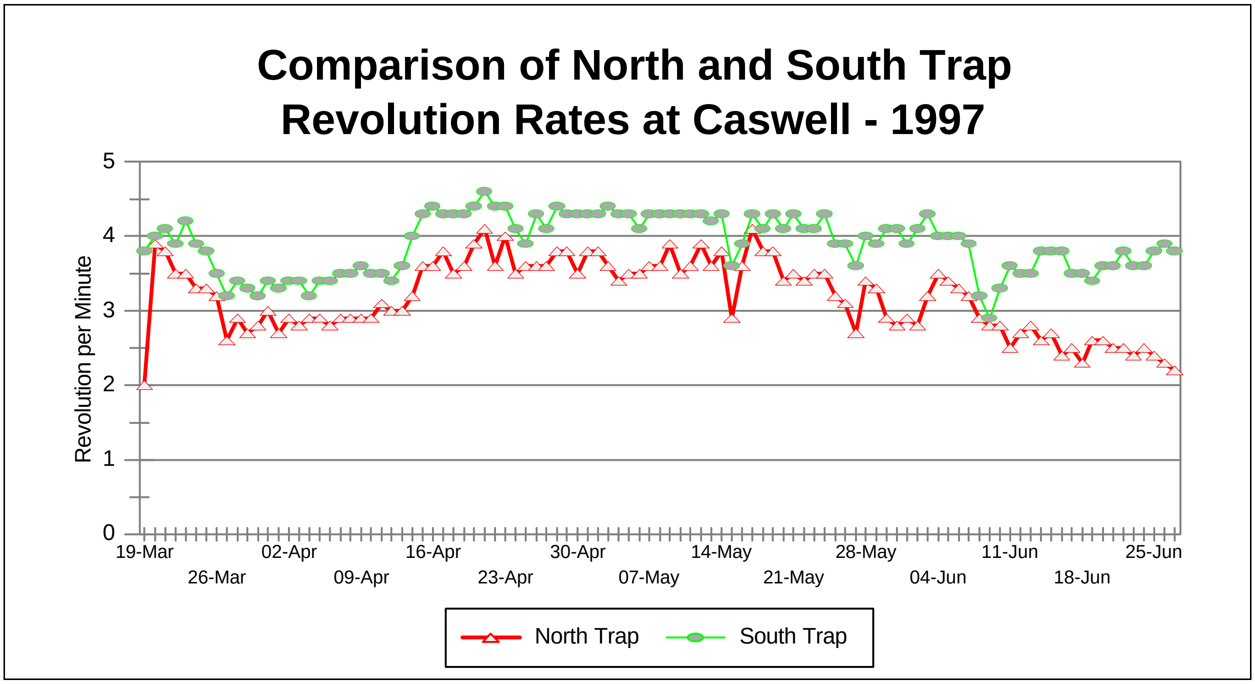
Appendix 4. Daily revolutions per minute and throat velocities of Caswell screw traps.

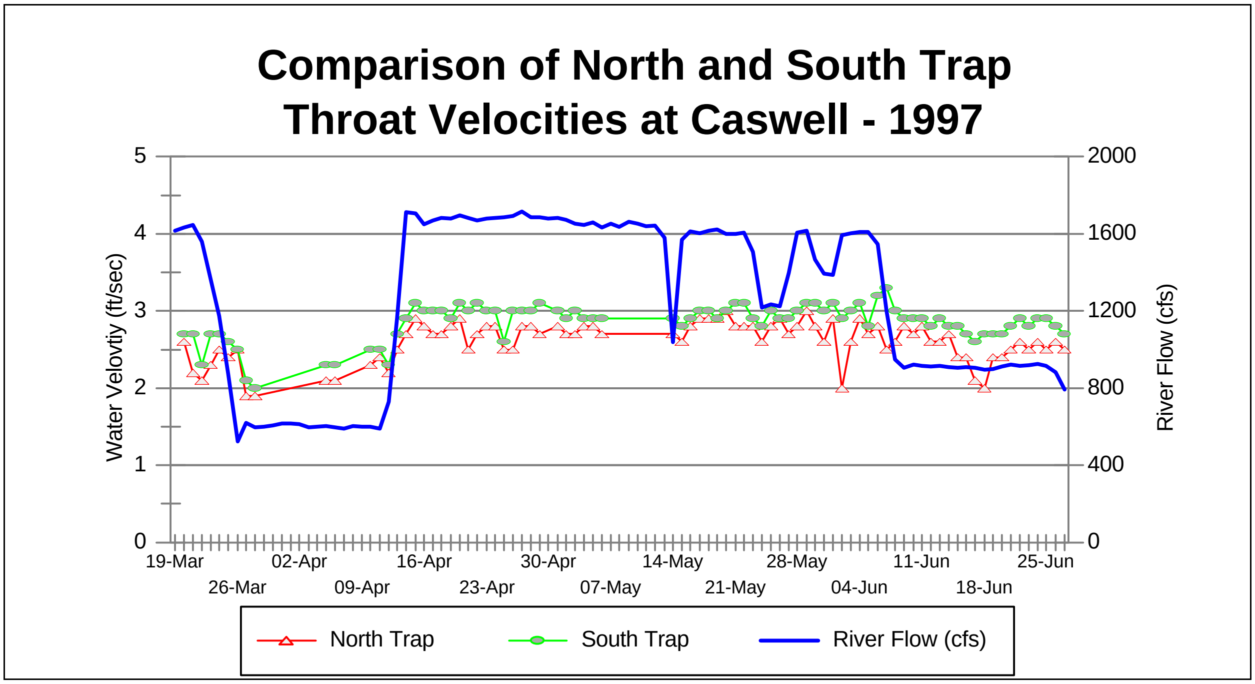
	Revolutions per Minute		Throat Velocity (ft/sec)		River
Date	North	South	North	South	Flow (cfs)
19-Mar	2	3.8	nd	nd	1618
20-Mar	3.9	4	2.6	2.7	1631
21-Mar	3.8	4.1	2.2	2.7	1645
22-Mar	3.5	3.9	2.1	2.3	1558
23-Mar	3.5	4.2	2.3	2.7	1362
24-Mar	3.3	3.9	2.5	2.7	1175
25-Mar	3.3	3.8	2.4	2.6	876
26-Mar	3.2	3.5	2.5	2.5	524
27-Mar	2.6	3.2	1.9	2.1	621
28-Mar	2.9	3.4	1.9	2	595
29-Mar	2.7	3.3	nd	nd	601
30-Mar	2.8	3.2	nd	nd	605
31-Mar	3	3.4	nd	nd	616
01-Apr	2.7	3.3	nd	nd	618
02-Apr	2.9	3.4	nd	nd	614
03-Apr	2.8	3.4	nd	nd	597
04-Apr	2.9	3.2	nd	nd	599
05-Apr	2.9	3.4	2.1	2.3	602
06-Apr	2.8	3.4	2.1	2.3	597
07-Apr	2.9	3.5	nd	nd	590
08-Apr	2.9	3.5	nd	nd	602
09-Apr	2.9	3.6	nd	nd	599
10-Apr	2.9	3.5	2.3	2.5	598
11-Apr	3.1	3.5	2.4	2.5	589
12-Apr	3	3.4	2.2	2.3	730
13-Apr	3	3.6	2.5	2.7	1164
14-Apr	3.2	4	2.7	2.9	1711
15-Apr	3.6	4.3	2.9	3.1	1707
16-Apr	3.6	4.4	2.8	3	1651
17-Apr	3.8	4.3	2.7	3	1668
18-Apr	3.5	4.3	2.7	3	1684
19-Apr	3.6	4.3	2.8	2.9	1680
20-Apr	3.9	4.4	2.9	3.1	1695
21-Apr	4.1	4.6	2.5	3	1685
22-Apr	3.6	4.4	2.7	3.1	1668
23-Apr	4	4.4	2.8	3	1679
24-Apr	3.5	4.1	2.8	3	--
25-Apr	3.6	3.9	2.5	2.6	1686
26-Apr	3.6	4.3	2.5	3	1691
27-Apr	3.6	4.1	2.8	3	1716
28-Apr	3.8	4.4	2.8	3	1685
29-Apr	3.8	4.3	2.7	3.1	1686
30-Apr	3.5	4.3	nd	nd	1680
01-May	3.8	4.3	2.8	3	1682
02-May	3.8	4.3	2.7	2.9	1672

Date	Revolutions per Minute North	Revolutions per Minute South	Throat Velocity (ft/sec) North	Throat Velocity (ft/sec) South	River Flow (cfs)
03-May	3.6	4.4	2.7	3	1653
04-May	3.4	4.3	2.8	2.9	1648
05-May	3.5	4.3	2.8	2.9	1659
06-May	3.5	4.1	2.7	2.9	1633
07-May	3.6	4.3	nd	nd	1653
08-May	3.6	4.3	nd	nd	1636
09-May	3.9	4.3	nd	nd	1662
10-May	3.5	4.3	nd	nd	1652
11-May	3.6	4.3	nd	nd	1639
12-May	3.9	4.3	nd	nd	1642
13-May	3.6	4.2	nd	nd	1581
14-May	3.8	4.3	2.7	2.9	1038
15-May	2.9	3.6	2.6	2.8	1571
16-May	3.6	3.9	2.8	2.9	1613
17-May	4.1	4.3	2.9	3	1602
18-May	3.8	4.1	2.9	3	1616
19-May	3.8	4.3	2.9	2.9	1621
20-May	3.4	4.1	3	3	1598
21-May	3.5	4.3	2.8	3.1	1600
22-May	3.4	4.1	2.8	3.1	1607
23-May	3.5	4.1	2.8	2.9	1506
24-May	3.5	4.3	2.6	2.8	1218
25-May	3.2	3.9	2.8	3	1233
26-May	3.1	3.9	2.9	2.9	1224
27-May	2.7	3.6	2.7	2.9	1398
28-May	3.4	4	2.8	3	1608
29-May	3.3	3.9	3	3.1	1615
30-May	2.9	4.1	2.8	3.1	1468
31-May	2.8	4.1	2.6	3	1395
01-Jun	2.9	3.9	2.9	3.1	1386
02-Jun	2.8	4.1	2	2.9	1594
03-Jun	3.2	4.3	2.6	3	1603
04-Jun	3.5	4	2.9	3.1	1611
05-Jun	3.4	4	2.7	2.8	1609
06-Jun	3.3	4	2.8	3.2	1547
07-Jun	3.2	3.9	2.5	3.3	1194
08-Jun	2.9	3.2	2.6	3	949
09-Jun	2.8	2.9	2.8	2.9	907
10-Jun	2.8	3.3	2.7	2.9	924
11-Jun	2.5	3.6	2.8	2.9	917
12-Jun	2.7	3.5	2.6	2.8	913
13-Jun	2.8	3.5	2.6	2.9	915
14-Jun	2.6	3.8	2.7	2.8	908
15-Jun	2.7	3.8	2.4	2.8	905
16-Jun	2.4	3.8	2.4	2.7	908
17-Jun	2.5	3.5	2.1	2.6	903
18-Jun	2.3	3.5	2	2.7	896
19-Jun	2.6	3.4	2.4	2.7	898
20-Jun	2.6	3.6	2.4	2.7	912

	Revolutions per Minute		Throat Velocity (ft/sec)		River
Date	North	South	North	South	Flow (cfs)
21-Jun	2.5	3.6	2.5	2.8	921
22-Jun	2.5	3.8	2.6	2.9	916
23-Jun	2.4	3.6	2.5	2.8	918
24-Jun	2.5	3.6	2.6	2.9	925
25-Jun	2.4	3.8	2.5	2.9	917
26-Jun	2.3	3.9	2.6	2.8	882
27-Jun	2.2	3.8	2.5	2.7	792

Temperature data taken each morning with hand-held thermometer.





Appendix 5. Daily minimum, maximum and mean river temperature at Caswell during 1997. Data from Onset data recorder that monitored temperature once

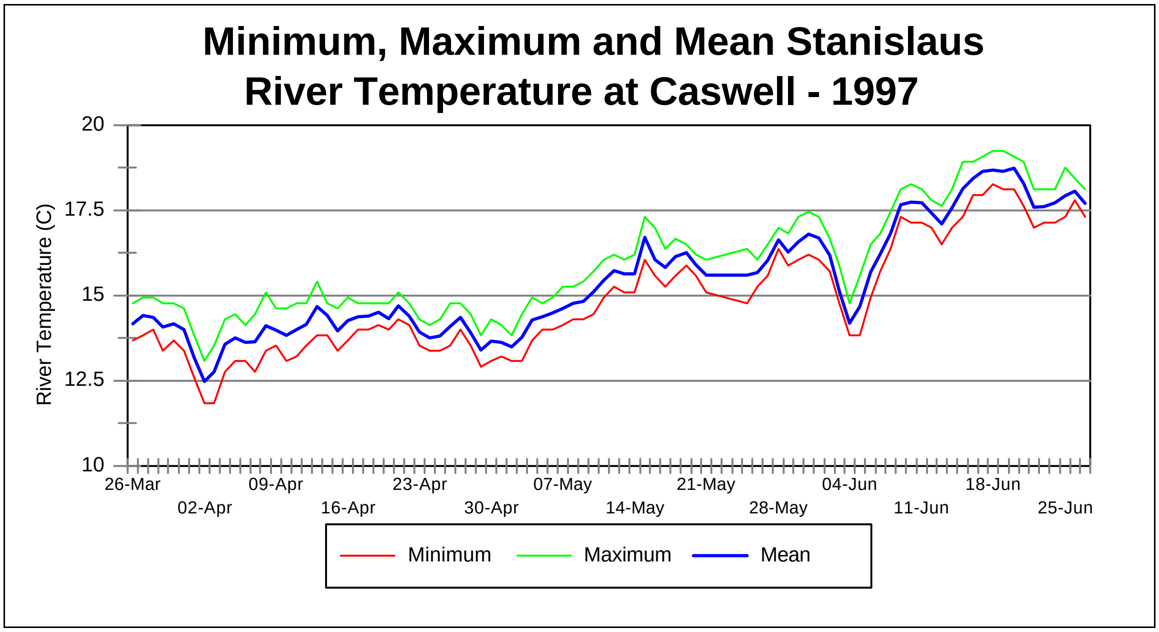
per hour.

	Recorder 1					
Date	Min Temp (C)	Min Temp (F)	Max Temp (C)	Max Temp (F)	Average Temp (C)	Average Temp (F)
26-Mar	13.7	56.6	14.8	58.6	14.2	57.5
27-Mar	13.8	56.9	14.9	58.9	14.4	57.9
28-Mar	14.0	57.2	14.9	58.9	14.4	57.8
29-Mar	13.4	56.1	14.8	58.6	14.1	57.3
30-Mar	13.7	56.6	14.8	58.6	14.2	57.5
31-Mar	13.4	56.1	14.6	58.3	14.0	57.2
01-Apr	12.6	54.7	13.8	56.9	13.2	55.7
02-Apr	11.8	53.3	13.1	55.5	12.5	54.5
03-Apr	11.8	53.3	13.5	56.4	12.8	55.0
04-Apr	12.8	55.0	14.3	57.7	13.6	56.4
05-Apr	13.1	55.5	14.5	58.0	13.8	56.8
06-Apr	13.1	55.5	14.1	57.5	13.6	56.5
07-Apr	12.8	55.0	14.5	58.0	13.6	56.5
08-Apr	13.4	56.1	15.1	59.2	14.1	57.4
09-Apr	13.5	56.4	14.6	58.3	14.0	57.2
10-Apr	13.1	55.5	14.6	58.3	13.8	56.9
11-Apr	13.2	55.8	14.8	58.6	14.0	57.2
12-Apr	13.5	56.4	14.8	58.6	14.1	57.5
13-Apr	13.8	56.9	15.4	59.7	14.7	58.4
14-Apr	13.8	56.9	14.8	58.6	14.4	58.0
15-Apr	13.4	56.1	14.6	58.3	14.0	57.1
16-Apr	13.7	56.6	14.9	58.9	14.3	57.7
17-Apr	14.0	57.2	14.8	58.6	14.4	57.9
18-Apr	14.0	57.2	14.8	58.6	14.4	57.9
19-Apr	14.1	57.5	14.8	58.6	14.5	58.1
20-Apr	14.0	57.2	14.8	58.6	14.3	57.8
21-Apr	14.3	57.7	15.1	59.2	14.7	58.5
22-Apr	14.1	57.5	14.8	58.6	14.4	57.9
23-Apr	13.5	56.4	14.3	57.7	13.9	57.1
24-Apr	13.4	56.1	14.1	57.5	13.7	56.7
25-Apr	13.4	56.1	14.3	57.7	13.8	56.9
26-Apr	13.5	56.4	14.8	58.6	14.1	57.4
27-Apr	14.0	57.2	14.8	58.6	14.4	57.9
28-Apr	13.5	56.4	14.5	58.0	13.9	57.0
29-Apr	12.9	55.2	13.8	56.9	13.4	56.1
30-Apr	13.1	55.5	14.3	57.7	13.7	56.6
01-May	13.2	55.8	14.1	57.5	13.6	56.5
02-May	13.1	55.5	13.8	56.9	13.5	56.3
03-May	13.1	55.5	14.5	58.0	13.8	56.8
04-May	13.7	56.6	14.9	58.9	14.3	57.7
05-May	14.0	57.2	14.8	58.6	14.4	57.9
06-May	14.0	57.2	14.9	58.9	14.5	58.1
07-May	14.1	57.5	15.3	59.5	14.6	58.3
08-May	14.3	57.7	15.3	59.5	14.8	58.6
09-May	14.3	57.7	15.4	59.7	14.8	58.7

	Recorder 1					
Date	Min Temp (C)	Min Temp (F)	Max Temp (C)	Max Temp (F)	Average Temp (C)	Average Temp (F)
10-May	14.5	58.0	15.7	60.3	15.1	59.2
11-May	14.9	58.9	16.0	60.9	15.4	59.8
12-May	15.3	59.5	16.2	61.2	15.7	60.3
13-May	15.1	59.2	16.0	60.9	15.6	60.1
14-May	15.1	59.2	16.2	61.2	15.6	60.1
15-May	16.0	60.9	17.3	63.2	16.7	62.1
16-May	15.6	60.0	17.0	62.6	16.0	60.9
17-May	15.3	59.5	16.4	61.4	15.8	60.5
18-May	15.6	60.0	16.7	62.0	16.1	61.0
19-May	15.9	60.6	16.5	61.7	16.3	61.3
20-May	15.6	60.0	16.2	61.2	15.9	60.6
21-May	15.1	59.2	16.0	60.9	15.6	60.1
22-May	nd	nd	nd	nd	nd	nd
23-May	nd	nd	nd	nd	nd	nd
24-May	nd	nd	nd	nd	nd	nd
25-May	14.8	58.6	16.4	61.4	15.6	60.1
26-May	15.3	59.5	16.0	60.9	15.7	60.2
27-May	15.6	60.0	16.5	61.7	16.0	60.9
28-May	16.4	61.4	17.0	62.6	16.6	61.9
29-May	15.9	60.6	16.8	62.3	16.3	61.3
30-May	16.0	60.9	17.3	63.2	16.6	61.8
31-May	16.2	61.2	17.5	63.4	16.8	62.2
01-Jun	16.0	60.9	17.3	63.2	16.7	62.0
02-Jun	15.7	60.3	16.7	62.0	16.2	61.1
03-Jun	14.8	58.6	15.9	60.6	15.1	59.2
04-Jun	13.8	56.9	14.8	58.6	14.2	57.6
05-Jun	13.8	56.9	15.6	60.0	14.7	58.4
06-Jun	14.9	58.9	16.5	61.7	15.7	60.3
07-Jun	15.7	60.3	16.8	62.3	16.2	61.2
08-Jun	16.4	61.4	17.5	63.4	16.8	62.3
09-Jun	17.3	63.2	18.1	64.6	17.7	63.8
10-Jun	17.1	62.9	18.3	64.9	17.7	63.9
11-Jun	17.1	62.9	18.1	64.6	17.7	63.9
12-Jun	17.0	62.6	17.8	64.0	17.4	63.4
13-Jun	16.5	61.7	17.6	63.7	17.1	62.8
14-Jun	17.0	62.6	18.1	64.6	17.6	63.6
15-Jun	17.3	63.2	18.9	66.1	18.1	64.7
16-Jun	18.0	64.3	18.9	66.1	18.4	65.2
17-Jun	18.0	64.3	19.1	66.3	18.7	65.6
18-Jun	18.3	64.9	19.2	66.6	18.7	65.6
19-Jun	18.1	64.6	19.2	66.6	18.6	65.6
20-Jun	18.1	64.6	19.1	66.3	18.7	65.7
21-Jun	17.6	63.7	18.9	66.1	18.3	64.9
22-Jun	17.0	62.6	18.1	64.6	17.6	63.6
23-Jun	17.1	62.9	18.1	64.6	17.6	63.7
24-Jun	17.1	62.9	18.1	64.6	17.7	63.9
25-Jun	17.3	63.2	18.8	65.8	17.9	64.3
26-Jun	17.8	64.0	18.4	65.2	18.1	64.5

	Recorder 1					
Date	Min Temp (C)	Min Temp (F)	Max Temp (C)	Max Temp (F)	Average Temp (C)	Average Temp (F)
27-Jun	17.3	63.2	18.1	64.6	17.7	63.9

Data from recorder #1. Recorder #2 was a back-up that produced similar values

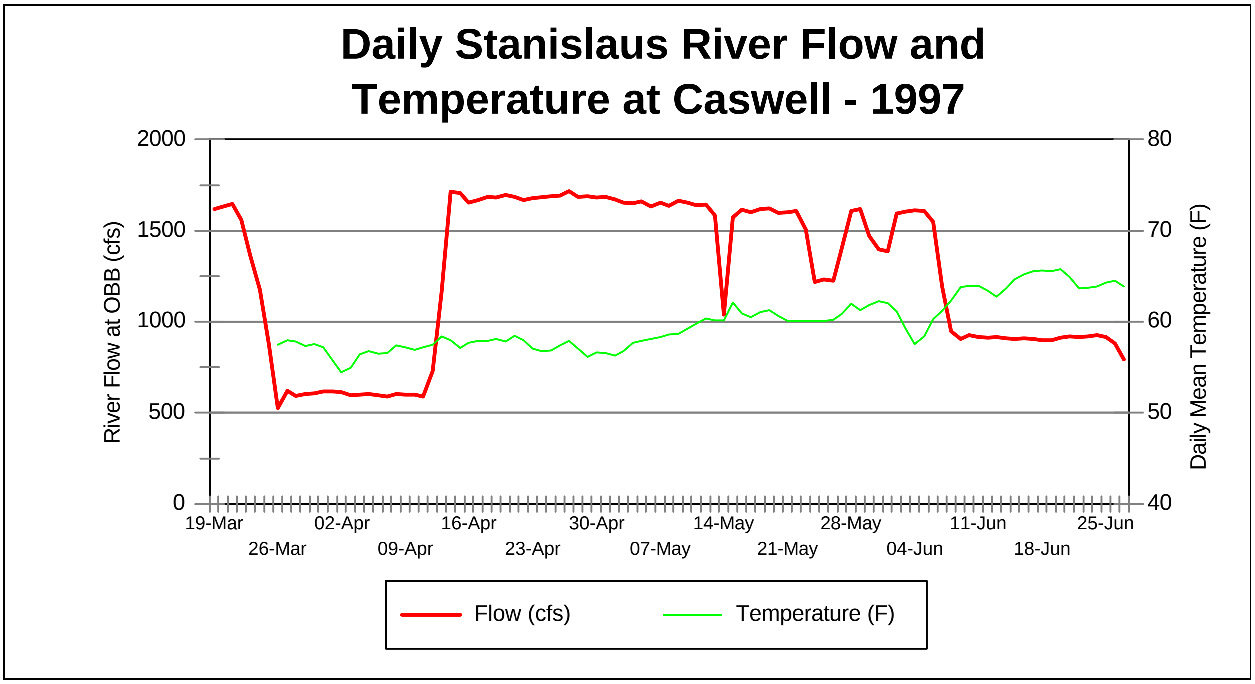


Date	Count	Out_Mig	Flow	Mean	M Temp (C)
02-Feb	-	-	7775		
03-Feb	-	-	7843		
04-Feb	-	-	7813		
05-Feb	-	-	7780		
06-Feb	-	-	7769		
07-Feb	-	-	7801		
08-Feb	-	-	7838		
09-Feb	-	-	7816		
10-Feb	-	-	7160		
11-Feb	-	-	4501		
12-Feb	-	-	3720		
13-Feb	-	-	3770		
14-Feb	-	-	3792		
15-Feb	-	-	4182		
16-Feb	-	-	5631		
17-Feb	-	-	6812		
18-Feb	-	-	7549		
19-Feb	-	-	7716		
20-Feb	-	-	7482		
21-Feb	-	-	7601		

Date	Count	Out Mig	Flow	Mean	M Temp (C)
22-Feb	-	-	7565		
23-Feb	-	-	7574		
24-Feb	-	-	7795		
25-Feb	-	-	8225		
26-Feb	-	-	8270		
27-Feb	-	-	8110		
28-Feb	-	-	6947		
01-Mar	-	-	6230		
02-Mar	-	-	6175		
03-Mar	-	-	6223		
04-Mar	-	-	5495		
05-Mar	-	-	4740		
06-Mar	-	-	4081		
07-Mar	-	-	3488		
08-Mar	-	-	2547		
09-Mar	-	-	1912		
10-Mar	-	-	1620		
11-Mar	-	-	1584		
12-Mar	-	-	1499		
13-Mar	-	-	1621		
14-Mar	-	-	1587		
15-Mar	-	-	1610		
16-Mar	-	-	1625		
17-Mar	-	-	1612		
18-Mar	-	-	1647		
19-Mar	15	278	1618	64.5	nd
20-Mar	17	399	1631	73.3	nd
21-Mar	35	568	1645	71.8	nd
22-Mar	36	710	1558	73.1	nd
23-Mar	48	841	1362	74.9	nd
24-Mar	42	649	1175	74.0	nd
25-Mar	32	410	876	73.5	nd
26-Mar	30	218	524	76.1	14.2
27-Mar	22	132	621	77.1	14.4
28-Mar	28	179	595	77.2	14.4
29-Mar	21	200	601	73.4	14.1
30-Mar	23	297	605	81.8	14.2
31-Mar	30	316	-	79.7	14.0
01-Apr	45	427	618	76.3	13.2
02-Apr	22	218	614	80.2	12.5
03-Apr	27	276	597	82.3	12.8
04-Apr	28	323	599	78.5	13.6
05-Apr	48	619	602	79.2	13.8
06-Apr	51	597	597	81.0	13.6
07-Apr	39	725	590	83.2	13.6
08-Apr	26	385	602	83.5	14.1
09-Apr	46	620	599	80.8	14.0
10-Apr	60	759	598	80.4	13.8
11-Apr	37	494	589	83.8	14.0
12-Apr	49	809	730	83.4	14.1

Date	Count	Out_Mig	Flow	Mean	M Temp (C)
13-Apr	45	722	1164	82.9	14.7
14-Apr	68	1222	1711	82.8	14.4
15-Apr	37	663	1707	81.3	14.0
16-Apr	37	777	1651	84.2	14.3
17-Apr	81	1699	1668	84.7	14.4
18-Apr	43	818	1684	83.6	14.4
19-Apr	22	309	1680	80.9	14.5
20-Apr	51	785	1695	85.0	14.3
21-Apr	28	500	1685	83.4	14.7
22-Apr	38	784	1668	85.4	14.4
23-Apr	10	222	1679	86.8	13.9
24-Apr	9	218	1680	85.0	13.7
25-Apr	26	682	1686	84.5	13.8
26-Apr	32	803	1691	85.2	14.1
27-Apr	15	397	1716	84.5	14.4
28-Apr	4	107	1685	90.0	13.9
29-Apr	21	627	1686	85.6	13.4
30-Apr	27	841	1680	87.6	13.7
01-May	3	86	1682	93.0	13.6
02-May	15	408	1672	86.6	13.5
03-May	42	1161	1653	86.3	13.8
04-May	28	796	1648	88.7	14.3
05-May	47	1327	1659	86.3	14.4
06-May	9	269	1633	91.0	14.5
07-May	32	959	1653	90.5	14.6
08-May	29	829	1639	88.4	14.8
09-May	31	967	1662	87.7	14.8
10-May	23	677	1652	86.1	15.1
11-May	21	632	1639	89.3	15.4
12-May	24	736	1642	86.0	15.7
13-May	35	1051	1581	88.1	15.6
14-May	31	575	1038	89.6	15.6
15-May	19	530	1571	90.9	16.7
16-May	52	1411	1613	90.7	16.0
17-May	5	137	1602	89.2	15.8
18-May	42	1238	1616	89.8	16.1
19-May	62	1778	1621	89.4	16.3
20-May	38	1051	1598	89.0	15.9
21-May	23	658	1600	88.4	15.6
22-May	30	864	1607	91.1	nd
23-May	0	0	1506	-	nd
24-May	12	236	1218	93.6	nd
25-May	31	617	1233	90.5	15.6
26-May	51	992	1224	88.6	15.7
27-May	11	237	1398	90.3	16.0
28-May	6	157	1608	90.2	16.6
29-May	42	1070	1615	90.6	16.3
30-May	2	47	1468	87.0	16.6
31-May	7	157	1395	90.4	16.8
01-Jun	3	66	1386	94.0	16.7

Date	Count	Out_Mig	Flow	Mean	M Temp (C)
02-Jun	11	298	1594	89.5	16.2
03-Jun	7	179	1603	89.3	15.1
04-Jun	2	48	1611	92.0	14.2
05-Jun	7	159	1609	86.6	14.7
06-Jun	8	177	1547	88.8	15.7
07-Jun	3	44	1194	86.0	16.2
08-Jun	2	22	949	92.5	16.8
09-Jun	6	55	907	90.2	17.7
10-Jun	3	27	924	93.7	17.7
11-Jun	7	65	917	93.9	17.7
12-Jun	6	55	913	88.0	17.4
13-Jun	5	48	915	86.8	17.1
14-Jun	3	30	908	92.3	17.6
15-Jun	2	20	905	93.5	18.1
16-Jun	6	68	908	86.3	18.4
17-Jun	1	13	903	88.0	18.7
18-Jun	3	36	896	92.0	18.7
19-Jun	4	46	898	94.5	18.6
20-Jun	3	37	912	98.0	18.7
21-Jun	4	51	921	89.3	18.3
22-Jun	4	56	916	92.0	17.6
23-Jun	2	27	918	94.5	17.6
24-Jun	1	15	925	92.0	17.7
25-Jun	0	0	917	-	17.9
26-Jun	0	0	882	-	18.1
27-Jun	0	0	792	-	17.7
28-Jun	-	-	800		
29-Jun	-	-	809		
30-Jun	-	-	733		
01-Jul	-	-	504		



Appendix 6. Physical data collected at Caswell during 1997.

Date	River Flow (cfs)	Turbidity (NTU's)	Hand-held Temp (F)	Daily Mean Temp (C)	Daily Mean Temp (F)	Weather Code
19-Mar	1618	11.8	nd	nd	nd	CLR
20-Mar	1631	10.4	54.1	nd	nd	CLD
21-Mar	1645	12.8	53.9	nd	nd	CLD
22-Mar	1558	11.1	53.9	nd	nd	CLR
23-Mar	1362	10.8	54	nd	nd	CLR
24-Mar	1175	10.6	54.1	nd	nd	CLR
25-Mar	876	10.2	54.3	nd	nd	CLR
26-Mar	524	12.1	56	14.2	57.5	CLR
27-Mar	621	14	56.1	14.4	57.9	CLR
28-Mar	595	13.4	57.8	14.4	57.8	CLR
29-Mar	601	10.7	55.8	14.1	57.3	CLR
30-Mar	605	8.7	56.1	14.2	57.5	CLR
31-Mar	616	10.1	56	14.0	57.2	CLR
01-Apr	618	10.8	55	13.2	55.7	CLR
02-Apr	614	nd	nd	12.5	54.5	CLR
03-Apr	597	10.2	56.2	12.8	55.0	CLR
04-Apr	599	9.4	56.5	13.6	56.4	CLR
05-Apr	602	8.7	58.5	13.8	56.8	CLR
06-Apr	597	9.3	57.5	13.6	56.5	CLR
07-Apr	590	6.3	57.8	13.6	56.5	CLR
08-Apr	602	7.8	58.2	14.1	57.4	CLR
09-Apr	599	8.4	58	14.0	57.2	CLR
10-Apr	598	8.8	58.8	13.8	56.9	CLR
11-Apr	589	8.4	59	14.0	57.2	CLR
12-Apr	730	7.8	59	14.1	57.5	CLR
13-Apr	1164	10.3	59.1	14.7	58.4	CLR
14-Apr	1711	12.5	59.3	14.4	58.0	CLR
15-Apr	1707	12.5	59.1	14.0	57.1	CLR
16-Apr	1651	11.2	59.1	14.3	57.7	CLR
17-Apr	1668	11.3	59.2	14.4	57.9	CLR
18-Apr	1684	12	59.3	14.4	57.9	CLR
19-Apr	1680	13.9	59.1	14.5	58.1	CLD
20-Apr	1695	13.4	58.5	14.3	57.8	CLR
21-Apr	1685	12.4	58.2	14.7	58.5	CLD
22-Apr	1668	11.4	58	14.4	57.9	CLD
23-Apr	1679	11	56.5	13.9	57.1	CLD
24-Apr	--	10.5	57	13.7	56.7	CLR
25-Apr	1686	10	56	13.8	56.9	CLR
26-Apr	1691	10.3	56	14.1	57.4	CLR
27-Apr	1716	10.1	56.2	14.4	57.9	CLR
28-Apr	1685	9.9	57	13.9	57.0	CLR
29-Apr	1686	9.2	55.5	13.4	56.1	CLR
30-Apr	1680	8.9	55.8	13.7	56.6	CLR
01-May	1682	9.4	55.8	13.6	56.5	CLR
02-May	1672	9.7	55.8	13.5	56.3	CLR
03-May	1653	9.5	55.8	13.8	56.8	CLR
04-May	1648	9.3	56	14.3	57.7	CLR
05-May	1659	9.4	58	14.4	57.9	CLR
06-May	1633	8.9	57	14.5	58.1	CLR

Date	River Flow (cfs)	Turbidity (NTU's)	Hand-held Temp (F)	Daily Mean Temp (C)	Daily Mean Temp (F)	Weather Code
07-May	1653	9	57.8	14.6	58.3	CLR
08-May	1636	9.2	57.5	14.8	58.6	CLR
09-May	1662	8.8	57	14.8	58.7	CLR
10-May	1652	9.1	57.5	15.1	59.2	CLR
11-May	1639	8.9	58	15.4	59.8	CLR
12-May	1642	8.8	58.5	15.7	60.3	CLR
13-May	1581	8.6	58.8	15.6	60.1	CLR
14-May	1038	8.7	58	15.6	60.1	CLR
15-May	1571	9	58.5	16.7	62.1	CLR
16-May	1613	9.4	57.8	16.0	60.9	CLR
17-May	1602	9.3	58	15.8	60.5	CLR
18-May	1616	8.9	58.5	16.1	61.0	CLR
19-May	1621	9.1	59	16.3	61.3	CLR
20-May	1598	9.2	52	15.9	60.6	CLR
21-May	1600	9	51	15.6	60.1	CLR
22-May	1607	nd	nd	nd	nd	CLD
23-May	1506	nd	nd	nd	nd	RAN
24-May	1218	nd	nd	nd	nd	CLR
25-May	1233	9.3	48	15.6	60.1	CLR
26-May	1224	9.4	nd	15.7	60.2	CLR
27-May	1398	9.7	60	16.0	60.9	CLR
28-May	1608	9.6	61	16.6	61.9	CLR
29-May	1615	9.8	61	16.3	61.3	CLR
30-May	1468	9.5	nd	16.6	61.8	CLR
31-May	1395	9.4	nd	16.8	62.2	CLR
01-Jun	1386	9.5	nd	16.7	62.0	CLR
02-Jun	1594	9.3	nd	16.2	61.1	CLR
03-Jun	1603	9.7	nd	15.1	59.2	RAN
04-Jun	1611	10.2	nd	14.2	57.6	RAN
05-Jun	1609	10.5	nd	14.7	58.4	CLR
06-Jun	1547	10.3	nd	15.7	60.3	CLR
07-Jun	1194	11.1	nd	16.2	61.2	CLR
08-Jun	949	11.5	nd	16.8	62.3	CLR
09-Jun	907	12.6	nd	17.7	63.8	CLR
10-Jun	924	12.9	nd	17.7	63.9	CLR
11-Jun	917	12.5	nd	17.7	63.9	CLR
12-Jun	913	12.6	nd	17.4	63.4	CLR
13-Jun	915	12.3	nd	17.1	62.8	CLR
14-Jun	908	11.9	nd	17.6	63.6	CLR
15-Jun	905	12.1	nd	18.1	64.7	CLR
16-Jun	908	nd	nd	18.4	65.2	CLR
17-Jun	903	10.2	nd	18.7	65.6	CLR
18-Jun	896	10.7	nd	18.7	65.6	CLR
19-Jun	898	11.0	nd	18.6	65.6	CLR
20-Jun	912	10.6	nd	18.7	65.7	CLR
21-Jun	921	10.5	nd	18.3	64.9	CLR
22-Jun	916	9.8	65.0	17.6	63.6	CLR
23-Jun	918	10.1	65.0	17.6	63.7	CLR
24-Jun	925	9.6	65.0	17.7	63.9	CLR

Date	River Flow (cfs)	Turbidity (NTU's)	Hand-held Temp (F)	Daily Mean Temp (C)	Daily Mean Temp (F)	Weather Code
25-Jun	917	10.3	65.0	17.9	64.3	CLR
26-Jun	882	10.7	65.0	18.1	64.5	CLR
27-Jun	792	11.4	64.0	17.7	63.9	CLR

"Hand-held" temperature data taken each morning with hand-held thermometer.
"Daily Mean" temperature recorded with data logger.

Appendix 7. Daily number of non-salmonids captured at Caswell during 1997.

Amercian Shad	AMS	Inland Silverside	MSS
Blue Gill	BGS	Pacific Lamprey	PL
Back Bullhead	BKB	Prickly Sculpin	PRS
Blach Crappie	BKS	Rainbow Trout (steelhead)	RBT
Brown Bullhead	BRB	Redear Sunfish	RES

Carp	C	Riffle Sculpin	RFS
California Roach	CAR	River Lamprey	RL
Channel Cat	CHC	Red Shinner	RSN
Chinook Salmon	CHNF	Sacramento Squawfish	SASQ
Delta Smelt	DSM	Sacramento Sucker	SASU
Flathead Minnow	FHM	Sacramento Blackfish	SCB
Goldfish	GF	Smallmouth Bass	SMB
Green Sunfish	GSF	Sacramento Splittail	SPLT
Golden Shinner	GSN	Striped Bass	STB
Hitch	HCH	Threadfin Shad	TFS
Hardhead	HH	Tule Perch	TP
Lamprey Unidentified	LAM	Warmouth	W
Largemouth Bass	LMB	White Catfish	WHC
Logperch	LP	White Crappie	WHS
Mosquito Fish	MQK	Yellow Bullhead	YEB

Date	AMS	BGS	BKB	BRB	C	CHC	CHNF	GF	GSN	HH	LAM	LMB	MQK	PKS	PL
03/19/97							15								
03/20/97					1		17	2					2		
03/21/97							35								
03/22/97							36								
03/23/97							48	2					2		
03/24/97	1						42	3				1			
03/25/97							32						3		
03/26/97							30						4		
03/27/97							22	1			1	1	1		
03/28/97							28					2			
03/29/97							21	1	1			1	3		
03/30/97							23			1					
03/31/97							30				1				1
04/01/97							45	1					1		
04/02/97				1			22								
04/03/97							27								
04/04/97							28								
04/05/97							48				4				1
04/06/97							51			1					
04/07/97							39	1							
04/08/97			1		1		26								
04/09/97							46						2		1
04/10/97							60	1			1				
04/11/97							37						1		
04/12/97							49					1			
04/13/97							45	1							
04/14/97							68	2		2			4		
04/15/97		1					37	2							
04/16/97							37	3			1		1		1
04/17/97							81	1					10		

Date	AMS	BGS	BKB	BRB	C	CHC	CHNF	GF	GSN	HH	LAM	LMB	MQK	PKS	PL
04/18/97					1		43						2		
04/19/97							22						1		
04/20/97							51						3		
04/21/97							28	1		1			7		
04/22/97							38						2		1
04/23/97							10	1					2		1
04/24/97							9						1		
04/25/97							26						1		
04/26/97							32	1		1			2		
04/27/97							15			1	2				3
04/28/97							4								
04/29/97							21				1				2
04/30/97			1				27						1		1
05/01/97							3								
05/02/97							15				1				
05/03/97							42	1							
05/04/97							28								2
05/05/97		1					47								
05/06/97							9			1	1		1		
05/07/97							32					1			
05/08/97							29						1		3
05/09/97							31								1
05/10/97							23				1	1			
05/11/97							21	2				1	1		
05/12/97							24				1				1
05/13/97							35	1							
05/14/97		1					31						2		1
05/15/97							19				1				
05/16/97		1				1	52				3				
05/17/97							5				2	1			
05/18/97							42					1			1
05/19/97							62				2	2			2
05/20/97							38				1	1	1		
05/21/97							23					1	1		
05/22/97							30								
05/23/97															
05/24/97							12				1				
05/25/97							31						1		
05/26/97					1		51					2			
05/27/97							11					1	1		
05/28/97							6					1			
05/29/97		1					42					1	1		
05/30/97							2						1		
05/31/97							7						1		
06/01/97							3								
06/02/97		1					11						1		
06/03/97							7				1		1		
06/04/97							2						1		
06/05/97							7						1		
06/06/97							8						1		

Date	AMS	BGS	BKB	BRB	C	CHC	CHNF	GF	GSN	HH	LAM	LMB	MQK	PKS	PL
06/07/97							3					1			1
06/08/97							2							1	
06/09/97							6						1		
06/10/97							3								
06/11/97			1				7					1	1		
06/12/97							6								
06/13/97							5					1			
06/14/97							3				1				1
06/15/97							2								
06/16/97							6								1
06/17/97							1					1			
06/18/97							3					1			
06/19/97							4					1			
06/20/97							3				2				
06/21/97							4								
06/22/97						1	4		2			1			
06/23/97			1				2								
06/24/97		1					1								
06/25/97															
06/26/97		1							1						
	1	8	4	1	4	2	2357	28	4	8	29	27	75	1	26

Date	PRS	RBT	RES	RFS	RL	RSN	SASQ	SASU	SMB	SPLT	TFS	TP	W	WHC	WHS
03/19/97							6								1
03/20/97							4								
03/21/97							3								
03/22/97							4								
03/23/97							5								
03/24/97							5								
03/25/97						1	2	1							
03/26/97						1	1								
03/27/97						1	3							1	
03/28/97							3								6
03/29/97		1				1	3	1							1
03/30/97						1									
03/31/97															
04/01/97															
04/02/97		1													
04/03/97															
04/04/97							1								
04/05/97															
04/06/97							1								1
04/07/97															
04/08/97															
04/09/97															
04/10/97									1					1	
04/11/97					1										
04/12/97															
04/13/97							1								

Date	PRS	RBT	RES	RFS	RL	RSN	SASQ	SASU	SMB	SPLT	TFS	TP	W	WHC	WHS
04/14/97														1	
04/15/97															
04/16/97					1										
04/17/97							2								1
04/18/97		1				2				1					
04/19/97			1												
04/20/97												1			
04/21/97														1	
04/22/97		1													
04/23/97											1				
04/24/97							1								
04/25/97															
04/26/97															
04/27/97															
04/28/97															
04/29/97		1						1							
04/30/97															
05/01/97		1													
05/02/97		1												1	
05/03/97															
05/04/97															
05/05/97															
05/06/97															
05/07/97							1								
05/08/97															
05/09/97															1
05/10/97								3							1
05/11/97														1	
05/12/97															
05/13/97															
05/14/97															
05/15/97															
05/16/97		1										2		1	
05/17/97												1			
05/18/97				1						1	1				
05/19/97								1							
05/20/97	1							1							
05/21/97	1					1	2	3							
05/22/97							1	1				2			
05/23/97															
05/24/97			1				1	1							
05/25/97															
05/26/97		1												1	1
05/27/97								2							1
05/28/97								1					1		
05/29/97		1						1							
05/30/97		1													
05/31/97								3							
06/01/97												1			
06/02/97								2						3	

Date	PRS	RBT	RES	RFS	RL	RSN	SASQ	SASU	SMB	SPLT	TFS	TP	W	WHC	WHS
06/03/97								1							
06/04/97								2							
06/05/97															
06/06/97															
06/07/97														1	
06/08/97														1	
06/09/97															
06/10/97															
06/11/97															2
06/12/97														1	
06/13/97														2	
06/14/97														1	
06/15/97								1							
06/16/97											1	1		1	
06/17/97							1								
06/18/97											1			3	
06/19/97															
06/20/97								1			1	1		1	
06/21/97											2			2	
06/22/97															
06/23/97												2			3
06/24/97															
06/25/97								2							
06/26/97								2							
	2	11	2	1	2	8	51	31	1	2	7	11	1	24	19

Appendix 8. Daily number of chinook measured, and their minimum, maximum and mean lengths in each trap at Caswell, 1997.

	North Trap				South Trap				Combined Traps			
Date	Number Measured	Min Length	Max Length	Mean Length	Number Measured	Min Length	Max Length	Mean Length	Number Measured	Min Length	Max Length	Mean Length
19-Mar	-	-	-	-	15	35.0	84.0	64.5	15	35.0	84.0	64.5
20-Mar	2	59.0	86.0	72.5	15	57.0	93.0	73.4	17	57.0	93.0	73.3
21-Mar	-	-	-	-	35	56.0	89.0	71.8	35	56.0	89.0	71.8
22-Mar	-	-	-	-	36	52.0	88.0	73.1	36	52.0	88.0	73.1
23-Mar	2	80.0	84.0	82.0	46	45.0	94.0	74.5	48	45.0	94.0	74.9
24-Mar	3	79.0	90.0	84.0	39	58.0	101.0	73.2	42	58.0	101.0	74.0
25-Mar	1	55.0	55.0	55.0	31	33.0	102.0	74.1	32	33.0	102.0	73.5
26-Mar	-	-	-	-	30	41.0	93.0	76.1	30	41.0	93.0	76.1
27-Mar	-	-	-	-	22	52.0	96.0	77.1	22	52.0	96.0	77.1
28-Mar	2	83.0	88.0	85.5	26	52.0	93.0	76.5	28	52.0	93.0	77.2
29-Mar	1	84.0	84.0	84.0	20	43.0	93.0	72.9	21	43.0	93.0	73.4
30-Mar	5	80.0	94.0	86.4	18	55.0	99.0	80.5	23	55.0	99.0	81.8
31-Mar	9	64.0	92.0	79.8	21	59.0	102.0	79.7	30	59.0	102.0	79.7
01-Apr	6	76.0	88.0	82.2	39	54.0	91.0	75.4	45	54.0	91.0	76.3

	North Trap				South Trap				Combined Traps			
Date	Number Measured	Min Length	Max Length	Mean Length	Number Measured	Min Length	Max Length	Mean Length	Number Measured	Min Length	Max Length	Mean Length
02-Apr	-	-	-	-	22	60.0	100.0	80.2	22	60.0	100.0	80.2
03-Apr	5	71.0	92.0	82.0	22	63.0	94.0	82.3	27	63.0	94.0	82.3
04-Apr	5	72.0	90.0	81.6	23	56.0	102.0	77.8	28	56.0	102.0	78.5
05-Apr	12	62.0	90.0	81.9	36	58.0	93.0	78.3	48	58.0	93.0	79.2
06-Apr	12	70.0	98.0	86.0	39	60.0	100.0	79.5	51	60.0	100.0	81.0
07-Apr	11	85.0	101.0	91.4	28	56.0	97.0	80.0	39	56.0	101.0	83.2
08-Apr	2	85.0	91.0	88.0	24	70.0	106.0	83.2	26	70.0	106.0	83.5
09-Apr	8	77.0	96.0	86.9	38	56.0	95.0	79.5	46	56.0	96.0	80.8
10-Apr	21	71.0	99.0	83.1	39	66.0	94.0	79.0	60	66.0	99.0	80.4
11-Apr	8	74.0	88.0	83.6	29	61.0	112.0	83.9	37	61.0	112.0	83.8
12-Apr	11	80.0	92.0	85.8	38	69.0	95.0	82.7	49	69.0	95.0	83.4
13-Apr	10	80.0	92.0	85.2	33	62.0	97.0	82.2	43	62.0	97.0	82.9
14-Apr	17	69.0	96.0	84.7	50	68.0	98.0	82.1	67	68.0	98.0	82.8
15-Apr	23	72.0	105.0	83.4	14	67.0	90.0	77.9	37	67.0	105.0	81.3
16-Apr	19	78.0	97.0	85.1	18	75.0	98.0	83.3	37	75.0	98.0	84.2
17-Apr	11	84.0	102.0	89.8	51	68.0	106.0	83.6	62	68.0	106.0	84.7
18-Apr	3	80.0	98.0	87.3	40	67.0	106.0	83.4	43	67.0	106.0	83.6
19-Apr	2	78.0	93.0	85.5	20	67.0	93.0	80.4	22	67.0	93.0	80.9
20-Apr	4	80.0	93.0	83.8	47	72.0	99.0	85.1	51	72.0	99.0	85.0
21-Apr	3	89.0	94.0	91.7	25	70.0	95.0	82.4	28	70.0	95.0	83.4
22-Apr	2	89.0	91.0	90.0	36	71.0	104.0	85.1	38	71.0	104.0	85.4
23-Apr	2	75.0	85.0	80.0	8	66.0	108.0	88.5	10	66.0	108.0	86.8
24-Apr	-	-	-	-	9	68.0	97.0	85.0	9	68.0	97.0	85.0
25-Apr	3	87.0	91.0	89.3	23	75.0	98.0	83.9	26	75.0	98.0	84.5
26-Apr	3	79.0	81.0	80.0	29	77.0	101.0	85.7	32	77.0	101.0	85.2
27-Apr	2	87.0	99.0	93.0	13	74.0	94.0	83.2	15	74.0	99.0	84.5
28-Apr	3	82.0	101.0	90.0	1	90.0	90.0	90.0	4	82.0	101.0	90.0
29-Apr	6	77.0	102.0	89.3	15	74.0	92.0	84.1	21	74.0	102.0	85.6
30-Apr	6	82.0	96.0	87.2	21	74.0	100.0	87.7	27	74.0	100.0	87.6
01-May	-	-	-	-	3	83.0	103.0	93.0	3	83.0	103.0	93.0
02-May	2	86.0	88.0	87.0	13	78.0	101.0	86.5	15	78.0	101.0	86.6
03-May	11	78.0	96.0	87.3	31	75.0	99.0	86.0	42	75.0	99.0	86.3
04-May	5	85.0	96.0	91.2	23	77.0	97.0	88.2	28	77.0	97.0	88.7
05-May	13	79.0	94.0	85.9	34	74.0	95.0	86.4	47	74.0	95.0	86.3
06-May	1	112.0	112.0	112.0	8	76.0	105.0	88.4	9	76.0	112.0	91.0
07-May	3	85.0	96.0	90.7	29	75.0	108.0	90.5	32	75.0	108.0	90.5
08-May	5	75.0	92.0	83.4	24	75.0	103.0	89.5	29	75.0	103.0	88.4
09-May	4	85.0	95.0	90.3	27	74.0	98.0	87.3	31	74.0	98.0	87.7
10-May	3	81.0	90.0	86.3	20	74.0	103.0	86.1	23	74.0	103.0	86.1
11-May	1	103.0	103.0	103.0	20	80.0	100.0	88.7	21	80.0	103.0	89.3
12-May	7	77.0	100.0	88.6	17	73.0	102.0	85.0	24	73.0	102.0	86.0
13-May	7	77.0	101.0	86.3	28	74.0	101.0	88.6	35	74.0	101.0	88.1
14-May	8	85.0	101.0	93.0	23	80.0	103.0	88.4	31	80.0	103.0	89.6
15-May	-	-	-	-	19	79.0	100.0	90.9	19	79.0	100.0	90.9
16-May	13	80.0	102.0	91.2	39	77.0	105.0	90.6	52	77.0	105.0	90.7
17-May	5	83.0	92.0	89.2	-	-	-	-	5	83.0	92.0	89.2
18-May	7	86.0	101.0	94.3	34	80.0	99.0	88.9	41	80.0	101.0	89.8
19-May	6	85.0	98.0	91.7	50	72.0	101.0	89.1	56	72.0	101.0	89.4

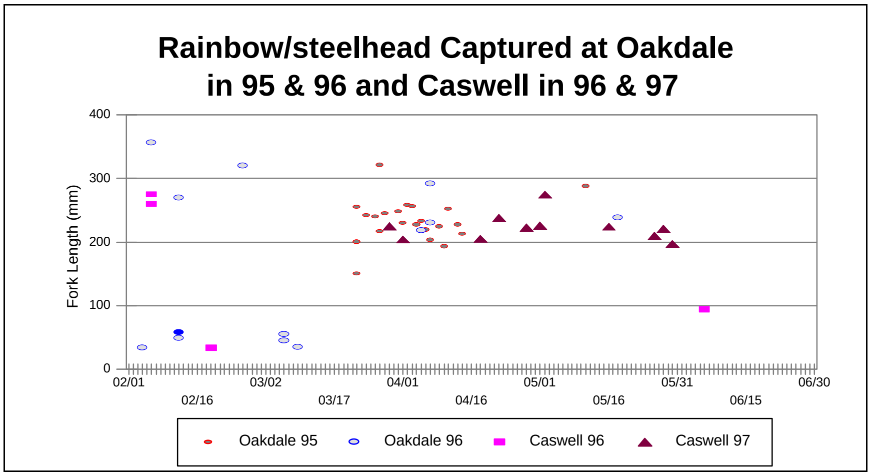
	North Trap				South Trap				Combined Traps			
Date	Number Measured	Min Length	Max Length	Mean Length	Number Measured	Min Length	Max Length	Mean Length	Number Measured	Min Length	Max Length	Mean Length
20-May	8	84.0	94.0	88.8	30	78.0	99.0	89.0	38	78.0	99.0	89.0
21-May	-	-	-	-	23	73.0	103.0	88.4	23	73.0	103.0	88.4
22-May	2	96.0	97.0	96.5	28	78.0	106.0	90.7	30	78.0	106.0	91.1
23-May	-	-	-	-	-	-	-	-	-	-	-	-
24-May	3	89.0	95.0	92.0	9	87.0	102.0	94.1	12	87.0	102.0	93.6
25-May	6	89.0	104.0	95.0	25	80.0	100.0	89.4	31	80.0	104.0	90.5
26-May	7	80.0	101.0	92.4	43	77.0	101.0	88.0	50	77.0	101.0	88.6
27-May	1	90.0	90.0	90.0	10	78.0	103.0	90.3	11	78.0	103.0	90.3
28-May	6	79.0	101.0	90.2	-	-	-	-	6	79.0	101.0	90.2
29-May	6	89.0	97.0	92.3	35	74.0	105.0	90.3	41	74.0	105.0	90.6
30-May	-	-	-	-	2	82.0	92.0	87.0	2	82.0	92.0	87.0
31-May	2	87.0	96.0	91.5	5	82.0	98.0	90.0	7	82.0	98.0	90.4
01-Jun	-	-	-	-	3	80.0	117.0	94.0	3	80.0	117.0	94.0
02-Jun	1	86.0	86.0	86.0	10	75.0	97.0	89.8	11	75.0	97.0	89.5
03-Jun	-	-	-	-	7	82.0	95.0	89.3	7	82.0	95.0	89.3
04-Jun	1	94.0	94.0	94.0	1	90.0	90.0	90.0	2	90.0	94.0	92.0
05-Jun	-	-	-	-	7	80.0	90.0	86.6	7	80.0	90.0	86.6
06-Jun	1	89.0	89.0	89.0	7	85.0	95.0	88.7	8	85.0	95.0	88.8
07-Jun	-	-	-	-	3	76.0	96.0	86.0	3	76.0	96.0	86.0
08-Jun	-	-	-	-	2	89.0	96.0	92.5	2	89.0	96.0	92.5
09-Jun	4	84.0	97.0	91.5	2	86.0	89.0	87.5	6	84.0	97.0	90.2
10-Jun	-	-	-	-	3	90.0	99.0	93.7	3	90.0	99.0	93.7
11-Jun	1	97.0	97.0	97.0	6	84.0	105.0	93.3	7	84.0	105.0	93.9
12-Jun	5	85.0	90.0	87.0	1	93.0	93.0	93.0	6	85.0	93.0	88.0
13-Jun	3	80.0	89.0	85.0	2	84.0	95.0	89.5	5	80.0	95.0	86.8
14-Jun	-	-	-	-	3	83.0	102.0	92.3	3	83.0	102.0	92.3
15-Jun	1	83.0	83.0	83.0	1	104.0	104.0	104.0	2	83.0	104.0	93.5
16-Jun	-	-	-	-	6	78.0	95.0	86.3	6	78.0	95.0	86.3
17-Jun	-	-	-	-	1	88.0	88.0	88.0	1	88.0	88.0	88.0
18-Jun	-	-	-	-	3	90.0	96.0	92.0	3	90.0	96.0	92.0
19-Jun	-	-	-	-	4	86.0	110.0	94.5	4	86.0	110.0	94.5
20-Jun	1	97.0	97.0	97.0	2	87.0	110.0	98.5	3	87.0	110.0	98.0
21-Jun	1	81.0	81.0	81.0	3	83.0	107.0	92.0	4	81.0	107.0	89.3
22-Jun	-	-	-	-	4	83.0	97.0	92.0	4	83.0	97.0	92.0
23-Jun	-	-	-	-	2	92.0	97.0	94.5	2	92.0	97.0	94.5
24-Jun	-	-	-	-	1	92.0	92.0	92.0	1	92.0	92.0	92.0
25-Jun	-	-	-	-	-	-	-	-	-	-	-	-
26-Jun	-	-	-	-	-	-	-	-	-	-	-	-
27-Jun	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 9. Date, number, length and smolt index rating for all rainbow trout/steelhead captured by SPCA in the Stanislaus River since 1993 Data does not include catches, if any, by CDFG and USFWS at Caswell in 1994 and 1995.

Date	Number	Fork Length (mm)	Smolt Index	Sampling Location
04/22/93	1	nd	nd	Oakdale
04/26/93	1	nd	nd	Oakdale
04/27/93	1	nd	nd	Oakdale
05/02/93	3	nd	nd	Oakdale
05/12/93	1	nd	nd	Oakdale
05/18/93	1	nd	nd	Oakdale
05/29/93	1	nd	nd	Oakdale
06/08/93	1	nd	nd	Oakdale
03/22/95	1	200	3	Oakdale
03/22/95	1	150	3	Oakdale
03/22/95	1	200	1	Oakdale
03/22/95	1	255	1	Oakdale
03/24/95	1	242	1	Oakdale
03/26/95	1	240	1	Oakdale
03/27/95	1	217	3	Oakdale
03/27/95	1	321	3	Oakdale
03/28/95	1	245	3	Oakdale
03/31/95	1	248	3	Oakdale
04/01/95	1	230	3	Oakdale
04/02/95	1	258	3	Oakdale
04/03/95	1	256	3	Oakdale
04/04/95	1	227	1	Oakdale

Date	Number	Fork Length (mm)	Smolt Index	Sampling Location
04/05/95	1	233	3	Oakdale
04/06/95	1	219	3	Oakdale
04/07/95	1	203	3	Oakdale
04/09/95	1	224	3	Oakdale
04/10/95	1	193	3	Oakdale
04/11/95	1	252	3	Oakdale
04/13/95	1	227	3	Oakdale
04/14/95	1	213	3	Oakdale
05/11/95	1	288	3	Oakdale
02/04/96	1	34	1	Oakdale
02/06/96	1	356	3	Oakdale
02/12/96	1	270	3	Oakdale
02/12/96	1	49	1	Oakdale
02/12/96	1	58	1	Oakdale
02/26/96	1	320	1	Oakdale
03/06/96	1	45	1	Oakdale
03/06/96	1	55	1	Oakdale
03/09/96	1	35	1	Oakdale
04/05/96	1	218	3	Oakdale
04/07/96	1	230	3	Oakdale
04/07/96	1	292	3	Oakdale
05/18/96	1	238	3	Oakdale
02/06/96	1	275	3	Caswell
02/06/96	1	260	3	Caswell
02/19/96	1	34	1	Caswell
06/06/96	1	94	2	Caswell
03/29/97	1	225	3	Caswell
04/01/97	1	204	3	Caswell
04/18/97	1	205	3	Caswell
04/22/97	1	238	3	Caswell
04/28/97	1	223	3	Caswell
05/01/97	1	226	3	Caswell
05/02/97	1	275	3	Caswell
05/16/97	1	224	3	Caswell
05/26/97	1	210	3	Caswell
05/28/97	1	221	3	Caswell
05/30/97	1	197	3	Caswell

nd = no data
Smolt Index: 1 = obvious parr; 3 = obvious smolt
All sampling conducted with rotary screw traps.
1993: One trap fishing at Oakdale.
1994: No sampling at Oakdale; CDFG sampled at Caswell. (rnb/stl catch unknown)
1995: One trap fishing at Oakdale; two at Caswell. (Caswell rnb/stl catch unknown)
1996: One trap fishing at Oakdale; two at Caswell.
1997: No trap at Oakdale; two at Caswell.



Appendix 10. Stanislaus River flow at Orange Blossom Bridge (OBB).

Stanislaus River Flow at Orange Blossom Bridge

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	6063	7731	6230	618	1682	1386	504	382	695			
2	6859	7775	6175	614	1672	1594	423	377	698			
3	5858	7843	6223	597	1653	1603	383	381	702			
4	6370	7813	5495	599	1648	1611	374	384	593			
5	6181	7780	4740	602	1659	1609	397	387	401			
6	6053	7769	4081	597	1633	1547	392	379	400			
7	6350	7801	3488	590	1653	1194	397	374	398			
8	7506	7838	2547	602	1639	949	373	376	403			
9	7254	7816	1912	599	1662	907	381	381	407			
10	7778	7160	1620	598	1652	924	383	379	411			
11	7902	4501	1584	589	1639	917	382	382	404			
12	7436	3720	1499	730	1642	913	384	380	403			
13	7028	3770	1621	1164	1581	915	364	380	402			
14	7742	3792	1587	1711	1038	908	386	385	402			
15	7547	4182	1610	1707	1571	905	389	395	401			
16	7444	5631	1625	1651	1613	908	394	385	403			
17	7915	6812	1612	1668	1602	903	-	381	402			
18	7810	7549	1647	1684	1616	896	395	379	398			
19	7509	7716	1618	1680	1621	898	381	369	401			
20	6629	7482	1631	1695	1598	912	378	385	405			
21	6826	7601	1645	1685	1600	921	372	376	410			
22	6841	7565	1558	1668	1607	916	372	401	417			
23	7399	7574	1362	1679	1506	918	374	396	410			
24	7557	7795	1175	1680	1218	925	384	368	407			
25	7656	8225	876	1686	1233	917	382	378	406			
26	6932	8270	524	1691	1224	882	382	404	454			
27	6716	8110	621	1716	1398	792	379	486	673			
28	7031	6947	595	1685	1608	800	381	721	679			
29	7229	-	601	1686	1615	809	383	705	687			

30	7549	-	605	1680	1468	733	380	700	682			
31	7771	-	-	-	1395	-	383	716	-			
count	31	28	30	30	31	30	30	31	30	31	30	31
Mean Flow	7121	6949	2270	1238	1547	1034	388	428	478	0	0	0

Mean Monthly Stanislaus River Flow

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1989	289	195	1022	834	1047	835	610	339	303	263	224	199
1990	147	155	876	480	414	596	579	494	278	204	176	169
1991	155	159	201	231	296	211	200	125	116	170	167	122
1992	122	218	222	754	288	233	259	271	293	298	214	213
1993	580	258	269	470	1444	472	399	286	240	588	355	322
1994	334	300	927	473	441	450	446	378	266	381	254	258
1995	590	251	623	911	1377	488	275	286	251	421	366	288
1996	620	1671	3259	1712	1426	969	705	497	358	511	534	3521
1997	7121	6949	2270	1238	1547	1034	388	428	478			
Ave.	317	219	591	593	758	469	416	316	249	317	232	214

Source: Daily data from CDEC. Monthly averages calculated from daily flow values.